POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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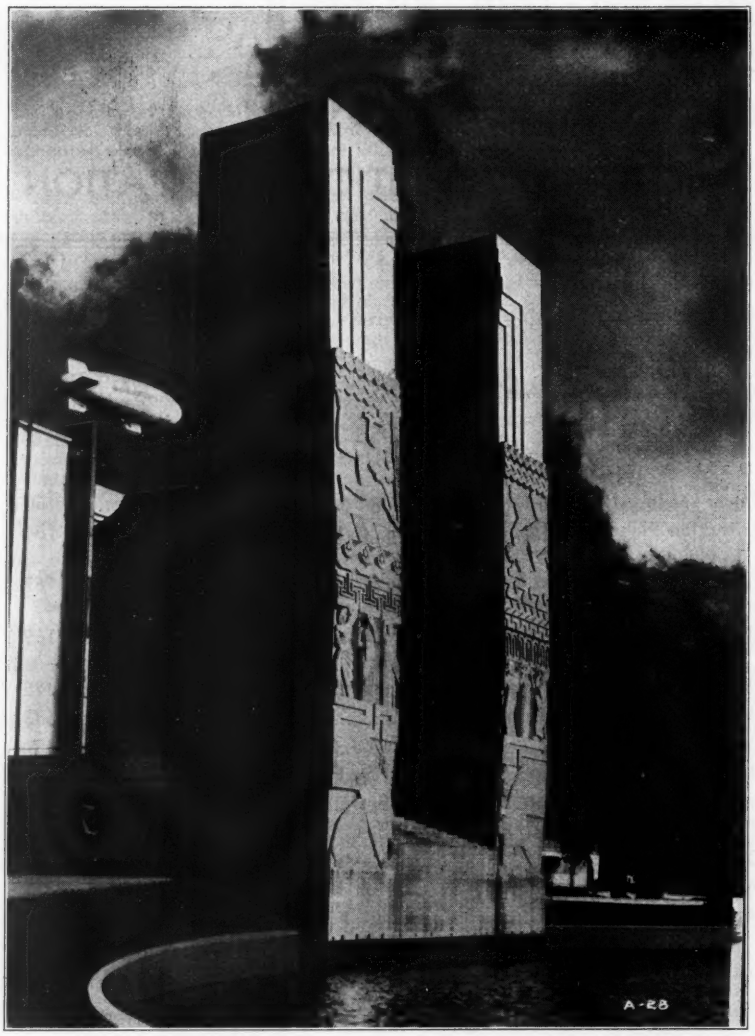


The Gateway to the Electrical Group at the "Century of Progress" in Chicago

Where Even the Stars Are Busy

ON THE SHORES of Lake Michigan at Chicago there is rising magically and majestically a dream city, as unique and daring in concept as it is beautiful and magnificent in proportion—a city born of the inspiration and idealism of a century of progress and achievement in the sciences, the arts and in industry. "A Century of Progress" is more than an exposition of interesting things and facts, of mere commercial display; it is the embodiment of a spirit—the spirit that made Chicago and so many other cities and towns of earlier days, a spirit of daring and courage that knows no obstacles. This spirit is reflected in every phase of its progress, from its inception in 1927 to its formal opening on June first by a beam from the giant star, Arcturus. In times like these, when confidence is none too prevalent elsewhere throughout this land, it is encouraging and comforting to know that there is at least one place where men are busy and hopeful, where business is booming and where construction is whirring along every hour, where even the stars are made to work. Indeed, it is an inspiration to visit the fair during its construction, to feel its throbbing activity, to absorb some of its vibrant energy.

Aside from its appeal as a thing of beauty and general interest, this exposition is of importance to us of the engineering profession because of its direct bearing on our work. For the central theme upon which "A Century of Progress" is founded, is the application of science and engineering to civilization. Here the dramatic story of man's progress through the discoveries of science will be unfolded; here each step in the evolution of a machine will be shown. But this is not all. If the exposition stopped merely with a presentation of historical data, a great opportunity would be lost. What is more important is that this age of scientific development is interpreted in terms of future human welfare—what its social consequences will be; in other words, how it will affect the "art of living." This is the real function of the exposition.

Naturally, the generation and utilization of mechanical power will occupy a dominant position, not only in the exhibits but also in the daily conduct of the exposition. The amount of electricity used for lighting in the Hall of Science alone will exceed that used at the entire World's Columbian Exposition in Chicago in 1893. In addition to the general scientific and electrical exhibits, the electric light and power industry is preparing a special exhibit in which twelve leading electric operating companies will cooperate.

Because of this direct relation to our industry, we are planning to devote the major portion of the June number of POWER PLANT ENGINEERING to "A Century of Progress," particularly as it relates to our field. We will endeavor to describe the exhibits of major importance in the mechanical, electrical and chemical arts and, as far as possible, indicate the relation of present day achievements to the future course of development. New discoveries in science will be emphasized and the consequences of fundamental research in the field of physics and chemistry will be brought out. Every effort will be made to present a comprehensive picture of the exposition with respect to our field.

WITH THE EDITORS

Synthetic Metals in the Power Plant

METALS ARE playing an increasingly more important part in the efficient and safe operation of power plants, due almost entirely to the discoveries made in the industrial laboratories of the United States and Europe. When it was found that metals served a purpose in the design of machinery that could not be accomplished by wood, the metals first employed were those found most abundantly in nature, that needed little treatment to condition them for use. It was soon found, however, that nature had endowed metals from different mines with highly different qualities, so that the qualities of natural irons are as varied as the surface waters of the country.

Every purpose for which a metal can be used is an individual problem of selection or development and requires an intimate knowledge of metals and their alloys. Up to the time of the World War little use was made in industry of steels treated to a dose of chromium, vanadium or nickel and it is noteworthy that at about this same time steam pressures and temperatures began to rise above the 250 lb. 100 deg. F. superheat stage.

Whereas in the pioneer days of power plants common metals and their simple alloys were the only ones known to the field, today metallurgists have developed alloys suited to almost any desired service and commercially pure metal is giving way to those specially treated and chemically combined to give them the qualities best fitted for the service.

A case in point is transformer iron which has had its hysteresis loss reduced to almost nothing by the removal of the intimately associated oxygen. Unquestionably the atomic structure of metals as it is being revealed by scientists today has much to do with the characteristics of all kinds of metals and alloys. Thus we may expect laboratory discoveries of metals that will greatly reduce electric and heat transfer losses, that are practically immune to corrosion or action of acids, that will maintain their strength at extremely high temperatures, that combine strength and low specific gravity to a degree not known today, that are non-combustible heat insulators, that will not transmit sound or other vibrations yet have the strength of metals like iron, that are slow to crystallize under reversing stress.

These and many more are the problems confronting the metallurgist in his laboratory, for the solutions of which designers of power plants have immediate need. Synthetic metals present a comparatively new but extremely important field of research.

Prosperity—A Problem

NEVER, probably, in the life of anyone now living has there been so grave a crisis as that through which we passed during the last month. Fear of collapse of our economic structure drove to panic thousands who had held steady during depression, lowered income and falling off in business. That fear has been dispelled by the courageous and intelligent action of President Roosevelt and his advisers in reëstablishing confidence in our banks. The country is to be congratulated on his leadership and on the cheerful steadiness with which his directions were followed.

With that crisis passed, the problem to be faced is how to reëstablish confidence in the ability of the country to produce, and buy goods.

In an analysis of the causes of the industrial depression, Will Durant gives, among others, tendency to disregard the obligation of contracts; reaction of conditions in foreign countries such as default in payments, decrease of purchasing power and depreciation of currencies; growth of power to produce, through invention and use of machinery and the use of power, faster than ability to buy; this latter has been due to too large a part of the gain from cheapened production being passed to those in control of business or wasted in top-heavy administration expense instead of being distributed to increase purchasing power by means of higher wages or lowered prices. To increase and spread buying power requires increase of *real* wages of workers either by greater income or lower prices, and to increase the impulse to buy calls for sufficient leisure to utilize and enjoy the products purchased.

Lower prices have been developing in a number of lines, but not yet have excessive administration expenses been sufficiently reduced. This lowering of prices has the double value of increasing *real* wages as measured in buying power and of attracting hoarded money into the market so as to make a greater demand for goods, which demand, passed on to production, will further increase buying power.

To get rid of excessive return to those in control of business and finance, it will be necessary to abolish exploitation and substitute service as the objective of business. Profit is necessary as the most powerful incentive to progress but not excessive profit, not get-rich-quick promotion such as has been the fashion among many of those who have heretofore been considered business and financial leaders.

To preserve prosperity and economic balance, goods must be bought as well as made. Economists are agreed that too much stress has been put on production to the neglect of distribution. To be bought, goods must be brought to the notice of those who can use them, i.e. advertised. The journal of an industry, which helps to build up that field of activity and serves those who are working in the industry, is the logical medium for such advertising, especially as it is a most important factor in progress of the industry. Under the system now existing, the work of a business journal can be done only with the patronage of manufacturers who want to sell in the field of that journal. It cannot live on the small income from subscription charges. Leading journals are so important to progress that it is vital that they receive adequate backing and readers, who wish the continued service of their journals, should be willing to aid in securing that backing by making clear to manufacturers their interest in advertised products and how that interest was aroused, so that manufacturers will increasingly appreciate the importance and effectiveness of this means of reaching the field they wish to cultivate and the desirability of furnishing the needed support.

POWER PLANT ENGINEERING April 1933

Power for t

By

CHARLES H. KNOWLES
Mechanical Equipment Engineer, Seattle, Wash.

SEVEN BUILDINGS included in the United States Marine Hospital group are located on the north slope of Beacon Hill, one mile southeast of the financial center of Seattle, Wash., and commanding a wonderful view of the city, Puget Sound, the Olympic and Cascade mountains and Mt. Rainier. Drawings and specifications for this work were prepared in the offices of Bebb & Gould, John Graham and associated architects, working with the supervising architect of the Treasury Department during the first 3 mo. of 1931. The contract for construction was let to N. P. Severin Co. of Chicago in May, 1931, and the building was completed during December, 1932.

The 320 bed hospital, the nurses' quarters and the boiler plant are located in the main building, which is a reinforced concrete structure 16 stories high faced with brick and trimmed with stone and terra cotta. It is 256 ft. long and 135 ft. wide, and includes two seven-story wings. The other buildings comprise an attendants' building, four double residences and one single residence for the officials. Completed, the buildings cost $1,600,000 exclusive of equipment and furnishings.

Electric power and water are purchased from the City of Seattle and gas from the Seattle Gas Co. Electricity is purchased for approximately $0.01 per kw.hr. so that it was not considered necessary to install a generating plant. Sewage is disposed of into the sewers of the city adjacent to the site. Piping is distributed horizontally chiefly on the basement ceiling and in the 6 ft. high pipe attic located between the 8th and 9th floors. This attic is below the operating room floor and houses the ventilating system and ducts serving that floor.

Boiler Plant

The main hospital building is located at the north side of the group of buildings and lowest on the slope so that the condensation from the other six buildings can return to the boiler by gravity flow.

Three Kewanee No. 322, 150 lb. w.p., double pass, portable, smokeless steel boilers, each rated at 20,000 sq. ft. of direct radiation when burning oil are installed. Each boiler has 1540 sq. ft. of heating surface or 1 sq. ft. to each 13 sq. ft. of rated capacity, a conservative rating as this type of boiler is sometimes rated as high as 1 sq. ft. of heating surface to 17 sq. ft. of heating load carried.

Boilers are placed on a 13 in. red brick wall lined with 4½ in. of firebrick and encased in a ¼ in. welded steel jacket to prevent cracks and air infiltration. This high setting gives a large furnace volume of 320 cu. ft., equal to 1 cu. ft. to each 4½ sq. ft. of boiler heating surface or to each 62½ sq. ft. of heating load. The safety valves are set for 125 lb. and steam is commonly generated at 100 lb. pressure. Each boiler is equipped with a feed water regulator and with an auxiliary hand controlled boiler feed line. Boiler outlet connections are equipped with a 6 in. globe stop check valve and a globe stop valve with a free drain between the valves.

Steam Distribution

High pressure steam at boiler pressure is used to drive boiler feed pumps, turbine driven vacuum pump and turbine driven oil pump. Steam reduced to 90 lb. pressure is supplied to the laundry while steam reduced from 90 to 60 lb. pressure is run to the 6 ft. pipe attic and distributed to the sterilizers.

Six sets of pressure reducing valves, each set consisting of two valves in parallel, with strainers and by-pass, are located in the pipe attic in a separate room lined with cork to absorb the sound of wire drawing steam. These reducing valves reduce the pressure of the steam from 60 to 5 lb. for distribution to the five zones into which the direct radiation is divided, and to the separate steam main serving the operating suite ventilating system, radiation and blanket warmers.

In the boiler room steam is reduced from 60 to 25 lb. pressure for distribution to the hot water generator, kitchen, heating coils for the ventilation system and to

the U. S. Marine Hospital at Seattle

the underground steam main leading to the detached buildings. Steam for the heating system is distributed by means of a vacuum return line system. Each of the six zones may be controlled by a graduated action pneumatic diaphragm valve located in pipe attic with switches on gage board in engineer's room.

Condensation from return risers for radiators located above pipe attic is collected in horizontal return mains in pipe attic and condensation from return risers from radiators located below pipe attic is collected in return mains on basement ceiling. Vacuum returns are gathered together and carried to the vacuum pumps which discharge into a 36 by 72 in. surge tank with cold water make-up with float control.

High pressure returns are taken through a condensate cooler before going to the surge tank in order to avoid flashing to steam of high pressure drips in the vented surge tank, and this serves to preheat the cold water supply to the lower domestic hot water system. The boiler feed pumps handle the water from the surge tank to the boilers.

Two vacuum pumps each have a capacity of 40,000 sq. ft. of radiation when drawing 10 in. vacuum and discharging against 20 lb. pressure with dual control for operating on vacuum or water level. One of them is driven by an electric motor and the other by a steam turbine operating with steam at 75 lb. pressure or above and exhausting into the 25 lb. steam line.

Two 6 by 4 by 6 in. horizontal, duplex, direct acting, piston packed, boiler feed pumps each having a capacity of 35 g.p.m. against 125 lb. boiler pressure when exhausting against a back pressure of 25 lb. are installed.

Oil Burner Equipment

The two buried steel oil storage tanks are 6 ft. in diameter and 30 ft. long, equipped with manholes and steam heating coils. One air turbine driven oil burner tip is provided for each boiler, and one motor driven and one steam turbine driven blower and pump set serve all the boilers. These burners are of sufficient capacity to burn enough oil of from 12 to 16 deg. Beaume gravity containing approximately 18,500 B.t.u. per pound to develop 175 per cent of the normal rating of each boiler. Steam heaters are provided in the oil lines adjacent to the boilers.

Oil burners are provided with devices to (a) regulate the quantity of oil and air, both primary and secondary, to the burners so as to maintain, practically constant, the desired steam pressure, (b) in case of electric current failure or low water to shut off the main oil supply, (c) in case of drop in pressure in oil supply line to burners below a predetermined minimum pressure to shut off the main oil supply from pumps, (d) upon failure of oil supply to burners or low water or failure of electric current, to ring an 8 in. electrically operated gong in boiler room.

In general, the hospital is not artificially ventilated. In the wards and offices the windows are equipped with window ventilators. The only areas supplied with forced ventilation fresh air are the operating suite on the ninth floor and the kitchens and dining rooms on the ground floor. The former is taken care of by a 53,000 c.f.m. outfit comprising fan, air washer, filter, heating coils, pneumatic automatic temperature and humidity control and the latter by a similar outfit with a capacity of 19,000 c.f.m. The other eleven fans are all exhaust fans ranging in size from the main kitchen exhaust, 19,000 c.f.m., and the general exhaust, 17,000 c.f.m., down to the little recreation room exhaust, 2900 c.f.m

Each fresh air intake leading to a fan and each discharge from an exhaust fan is equipped with a damper arranged for pneumatic control, so that the damper will be open when the fan is running and closed when the fan is stopped. The electrical controls for the fans are so inter-connected with the pneumatic control sys-

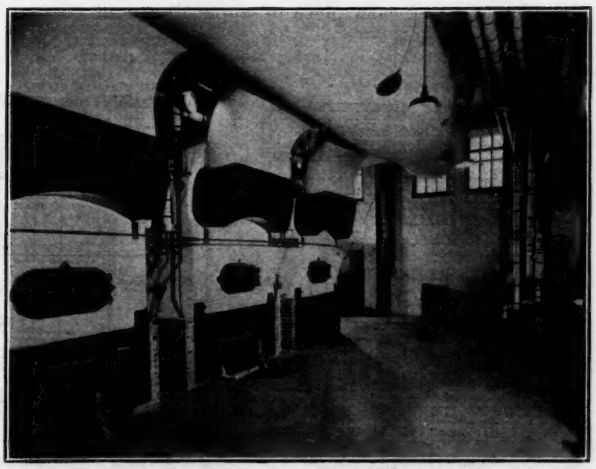


FIG. 1. FRONT VIEW OF BOILERS WITH THE OIL BURNER PUMP AND FAN SETS IN THE CORNER AND THE BOILER ROOM VENTILATING FAN ON THE PLATFORM ABOVE. DUE TO EXPANSION AND CONTRACTION THE BRICK FOUNDATIONS CRACKED AND WERE ENCLOSED WITH A WELDED SKIRT OF ¼ IN. BOILER PLATE GROUTED TO THE BRICKWORK

tem that no attention to the dampers on the part of the operator is required when starting and stopping the fans. Fans have double curved blades, and horsepower curves with self-limiting characteristics. Tip speeds of fans have been restricted to 5000 ft. per min. or less and outlet velocities at the point of cut-off to not more than 1500 ft. per min. Oil filters filter the air supply to ventilating systems.

An interesting feature of the automatic humidity control is that it is used to prevent the trouble frequently encountered in operating rooms from explosions of ether due to sparks of static electricity. The control for the operating suite apparatus is set to maintain a dew point of 62 deg. F. at the discharge end of the washer. This

FIG. 2. REFRIGERATING MACHINE ROOM WITH THE ICE TANK IN THE FOREGROUND

gives a relative humidity of 65 per cent at a room temperature of 75 deg. F. which is so high that no danger from static electricity exists. This does away with the necessity for an expensive brass grille in the floor and the grounding of each piece of apparatus used.

CALCULATION OF STEAM LOADS

	Equivalent C. I. Radiation Sq. Ft.
Laundry—61 B.H.P. × 34.5 = 2100 lb. steam per hr. × 4	8,400
Kitchen—25 B.H.P. × 34.5 = 860 lb. steam per hr. × 4	3,440
H. W. Generator (Laundry & Kitchen) — (1500 G.P.H. × 140 × 8.3) ÷ 240	7,250
H. W. Generator (Lower System)—(2000 G.P.H. × 140 × 8.3) ÷ 240	9,700
H. W. Generator (Upper System)—(1000 G.P.H. × 140 × 8.3) ÷ 240	4,850
Heating System (Hospital Bldg.), including 10 per cent for mains	27,910
Sterilizers—25 B.H.P. × 34.5 = 860 lb. steam per hr. × 4	3,440
4—Double Residences, incl. domestic hot water, each 2260 sq. ft.	9,040
1—Officer in Charge Residence, including domestic hot water	1,310
Attendants' Home, including domestic hot water	5,230
Garage Heating	1,000
Operating Room Ventilating System	1,550
Kitchen and Dining Room Ventilating System	7,000
MAXIMUM POSSIBLE TOTAL DEMAND, SQ. FT.	90,120

Use 70 per cent demand factor or 70 per cent of 90,120 equals 63,000 sq. ft. for two boilers.
Boilers at 150 per cent rating, normal rating for each boiler = 63,000 ÷ (2 × 1.5) = 21,000 sq. ft.
Calculations based on two boilers but three were installed so that a spare boiler would always be ready to insure continuity of service.

Calculations for Water Supply

Water supply for the main hospital building was based on an ultimate maximum capacity of 420 beds. The maximum instantaneous flow of cold water was taken as one gallon per minute per bed, or 420 g.p.m. of cold water; that for the hot water as 0.36 g.p.m. per bed, or 150 g.p.m. and pipes were sized for friction loss and calculations for storage capacity for hot water and for heating capacities of steam coils were based on these assumptions. These quantities took care of the kitchen, but for the laundry, 100 g.p.m. each of hot and of cold water additional was provided. The maximum instantaneous flow of water for all purposes for this building (both hot and cold) is therefore 750 g.p.m., or 1.8 g.p.m. per bed.

Rate of flow of hot water for all purposes other than laundry for the maximum 15 min. was assumed as 135 g.p.m., or 0.32 g.p.m. per bed. For the maximum hour it was assumed that 5000 gal. of hot water would be used, or at the rate of 83 g.p.m., or 0.20 g.p.m. per bed. The assumed rate for the maximum 15 min. is 90 per cent of the rate at the maximum instant. The assumed

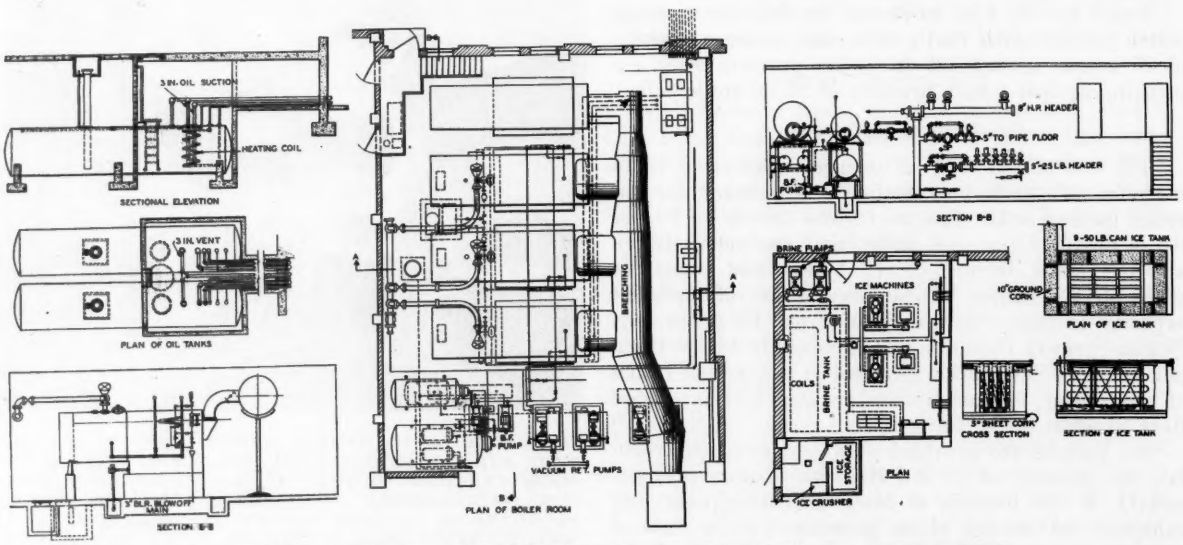


FIG. 3. PLAN AND SECTION OF THE BOILER AND REFRIGERATING MACHINE ROOMS

rate for the maximum hour is 62 per cent of the rate during the maximum 15 min.

Hot water storage for ordinary plumbing uses (other than kitchen and laundry) was provided in the amount of 5.6 gal. per bed and heating capacity at the rate of 7.1 gal. per bed. Hot water storage for the laundry and kitchen was provided in the amount of 2.8 gal. per bed and heating capacity at the rate of 3.5 gal. per bed. It was assumed that there would be 8 lb. of wash per day per bed and that for each 100 lb. of dry wash there would be used 200 gal. of cold and 150 gal. of hot water, 50 lb. of steam and 2 kw. of electricity.

The hot water storage tank for the lower system has a storage capacity of 1700 gal. and a heating element capable of heating 2000 gal. per hr. from 40 to 180 deg. F. with steam at 25 lb. pressure; that for the upper system has a storage capacity of 650 gal. and a heating element rated at 1000 gal. per hr.; that for the laundry and kitchens has a storage capacity of 1190 gal. and a heating capacity of 1500 gal. per hr.; and that for the attendants' building, storage of 310 gal. and heating capacity of 400 gal. per hr.

The refrigeration plant is located in a room on the ground floor which has no opening into the hospital corridor, the only entrance being through two outside doors so that should ammonia escape, it will not get into the hospital.

Plant is competent to perform the following functions: make 450 lb. opaque ice per day; make 50 gal. of ice cream per day over an hour period (freezing to soft, only, as hardening is done in a separate system); cool the several boxes and compartments.

Conduit and wiring system includes wiring for light and power, special feeders for the elevator machines, and for the X-Ray; conduit for telephones of the telephone company and for clocks; a conduit and wiring system for radio, conduit, wiring and apparatus for nurses' bedside call system, for house telephones, and for a fire alarm system; and underground conduit system and cables for light and power, telephone, and fire alarm; also exterior lighting standards and cable.

A transformer vault is provided in connection with the main building in which are installed three 100 kv.a., 4330 v.; three 150 kv.a., 4330 v.; one 75 kv.a., 2400 v. and one 150 kv.a., 2400 v. single phase, 60 cycle, oil cooled, submersible subway type transformers for step-down service. In each primary lead feeding a transformer bank 5000 v. oil fuse cutouts are installed. Wiring for lighting is on the 3-phase, 4-wire, alternating current, 120-208 v. system, converted at the distribution panels to 2-wire, 120 v. system.

The main switchboard is of the dead front safety type with live parts on rear completely protected by removable sheet steel panels. Two main circuit breakers

EQUIPMENT AND MATERIALS IN U. S. MARINE HOSPITAL

Plumbing Fixtures	Kohler Co.
Brass Pipe	Revere Copper Co.
Acid Proof Waste Pipe	Pacific Foundry Co.
Water Heater and Storage Tank	Sims Co.
Regulators for Tank	Sarco Co.
Water Supply Valve	Kieley & Mueller Co.
Back Water Valves	American Foundry & Mfg. Co.
Grease Traps	Josam Mfg. Co.
Fire Hose Reels	W. D. Allen Mfg. Co.
Covering for Plumbing	Philip Carey Co.
Cast Iron Pipe	United States Cast Iron Pipe & Foundry Co.
Cast Iron Soil Pipe and cast iron, malleable, drainage and brass fittings	Crane Co.
Boilers	Kewanee Boiler Corp.
Blow-off Valves	Crane Co.
Stop and Check Valves	McAlear Mfg. Co.
Converters	Sims Co.
Thermostats	Powers Regulator Co.
Radiators	American Radiator Co.
Pipe Hangers and Radiator Brackets	Crawford Co.
Copper Tube Radiators	Rome Brass Radiator Co.
Radiator Shields	Pacific Radiator Shield Co.
Copper Tube Heaters	Buffalo Forge Co.
Air Relief Valves	Mueller Co.
Radiator Valves	Jas. P. Marsh Co.
Reducing Valves	Kieley & Mueller Co.
Back Pressure Valves	McAlear Mfg. Co.
Pump Governors	McAlear Mfg. Co.
Steam Flow Meters	Brown Instrument Co.
Draft Gauge	Hays Corp.
Incinerator	Midwest Incinerator Co.
Thermostatic Traps	Jas. P. Marsh Co.
Feed Water Regulators	Northern Equipment Co.
Combination Traps	Jas. P. Marsh Co.
Boiler Feed Pumps	Economy Pumping Mach'y Co.
Vacuum Pumps	Economy Pumping Mach'y Co.
Expansion Joints	Economy Pumping Mach'y Co.
Fans	Buffalo Forge Co.
Motors and Drive for Fans	Allis Chalmers Mfg. Co.
Air Filters	Independent Air Filter Co.
Air Washers	Buffalo Forge Co.
Air Washer Humidity Control	Powers Regulator Co.
Pipe Covering	Philip Carey Co.
Wood Log Covering for Underground steam and return pipes	Federal Pipe & Tank Co.
Oil Burners	Petroleum Heat & Power Co.
Refrigeration Compressor	York Ice Machinery Corp.
Motor for Compressor	Westinghouse Electric & Mfg. Co.
Brine Circulating Pumps	Buffalo Steam Pump Co.
Motors for Brine Pumps	Westinghouse Electric & Mfg. Co.
Brine Agitator Pumps	York Ice Machinery Corp.
Motor for Brine Agitator Pump	Master Electric Co.
Ice Cream Freezer	York Ice Machinery Corp.
Motor for Ice Cream Freezer	Robbins & Myers Co.
Cork Covering	Cork Importing Co.
Steel Shelving	Victor Products Corp.
Ice Crusher	Champion Engine Co.
Unit Electric Refrigerators, Coolers and Ice Cream Equipment	Frigidaire Corp.
Laundry Equipment	Troy Laundry Machinery Co., Inc.
Electrical Switchboard and Panels	Trumbull Electric Co.
Rubber Covered Wire	Hazard Wire Rope Co.
Flush Switches, receptacles, plates	Hart & Hegeman Co.
Air Circuit Breakers	Roller-Smith Co.
Ground Lighting Cables	Hazard Wire Rope Co.
Automatic Sprinkler Heads	Viking Corp.
Alarm Valves	Viking Corp.
Emergency Lighting Unit	Electric Storage Battery Co.
Telephone, Call and Alarm System	Holtzer Cabot Electric Co.
Lighting and Power Transformers	Standard Transformer Co.
Oil Fuse Cutouts	General Electric Co.
Motor Starters	Allen-Bradley Co.
Fuses	Economy Fuse & Mfg. Co.
Radio Wire	John A. Roebling's Sons Co.

In this room is located the equipment consisting of two 5 by 5 in. motor driven vertical single acting ammonia compressors, condensers, receivers, brine and freezing tanks, brine pumps and ice crusher.

The ammonia compressors operate automatically on the brine tank keeping the temperature of brine between plus 1 deg. and plus 5 deg. Brine pumps operate continuously and supply brine to the various rooms and compartments, ice freezing tank and ice cream freezer. Each compressor and each pump is of sufficient capacity to carry the entire load. The ice freezing tank is separate from main brine tank and coils therein are connected to brine circulating system.

are provided. All feeders from switchboards are controlled by fused switches.

Operating room lights, exit lights, corridor lights and stair lights are on special circuits wired from separate panel boards which are fed from an emergency lighting section of the main switchboard. The emergency lighting system consists of a storage battery of capacity sufficient to carry a total emergency load of 4500 w. for a period of 2 hrs., a control panel to transfer the emergency lighting circuit from the normal supply to the battery upon failure of the normal supply and to reconnect the emergency circuit automatically to the normal supply when the service is restored.

POWER PLANT ENGINEERING April 1933

This is the first of a series of articles on the practical design application and installation of extraction heaters for power plant service. The next article in the series will be by Frank R. Wheeler and will discuss the practical design of the heater itself, heat transfer coefficients, size and gage of tubes, number of passes and friction loss. Mr. Wheeler's many years' experience as an engineer, designer and manufacturer of condensers and heat transfer equipment well qualifies him for the title of Dean of that field.

EXTRACTION HEATERS *in the* POWER PLANT

By
GUSTAF A. GAFFERT

USE OF EXTRACTION HEATERS in central station practice, as well as in industrial power stations, for the purpose of increasing the efficiency of energy conversion has become accepted practice. A comparison of the increase of efficiency for a single stage of reheat versus a few stages of extraction may indeed be in favor of extraction as a method of increasing station economy.

Although it may seem somewhat elementary to the reader, the writer believes that a conception, and proper evaluation, of the essential economic factors in extraction heater selection can be obtained only from a thermodynamic viewpoint, and an analysis will first be developed from that point of view. There are many stations operating on the extraction cycle and, in general, they can be classified, according to the throttle pressure as belonging to the 400, 600, 900, 1200 and 1500 lb. class or in light of the known physical properties of available metals for design according to initial temperature. We find temperatures of 700 to 750 deg. F. rather common with an occasional station having 800 and one or two experimental plants with an initial temperature of 1000 deg. F.

GUSTAF A. GAFFERT is eminently qualified to discuss both the theory and practice of power plant design for both industrial and central station practice. For five years from 1927 to 1932 he was an engineer in the mechanical engineering department of Sargent & Lundy, Inc., of Chicago. Two of the five years were devoted to test work and reports on power projects and industrial plant design, the last three years to central station design.

Mr. Gaffert was graduated from Worcester Polytechnic Institute with a degree of B.S. in Mechanical Engineering in 1923 and after two additional years as graduate assistant was granted the professional degree Mechanical Engineer in 1925. For the two years, 1925 to 1927, he was an instructor in mechanical engineering at the University of Illinois before joining the Sargent & Lundy organization in 1927. He is now graduate student at the University of Michigan working for a doctor's degree in engineering.

After this article, telling how to determine the most economic feedwater temperature, number of heaters and cycle efficiencies, Mr. Gaffert will give practical data on installation, draining, venting, piping and accessories.

If we select a plant of say 1200 lb. absolute initial pressure and 800 deg. F. total temperature with an absolute back pressure of 1 in. Hg. abs., typical of the modern trend, we may make the following analysis. The first consideration in an extraction cycle is the desirable number of heaters to be installed. Such an analysis is readily made from the steam temperature-entropy diagram, a small portion of which is shown in Fig. 1. Assume for the sake of simplification that the expansion in the turbine is isentropic or at constant entropy, and in this case, starts at the point E when the temperature is 800 deg. F. and the entropy 1.5431. We have two variables to deal with; the final temperatures to which feedwater is to be preheated before being fed to the boiler; and the number of stages of feed heating to be selected. In order to attain maximum benefit from extraction it is desirable to locate the heaters so that the total temperature increase is divided into equal temperature steps.

While it would be tiresome to reproduce computations, the general method may be outlined, assuming a final feed temperature of 450 deg. F. and six heaters. In order to obtain a feedwater temperature of 450

deg. F., steam for the highest pressure heater must be extracted from the turbine at approximately 535 deg. F. and 422.6 lb. abs., since, upon condensation, feedwater may be heated only to the saturation temperature corresponding to the pressure of the extracted steam. The temperature range from 79 (corresponding to 1 in. Hg. abs.) to 450 deg. F. has been arbitrarily divided into six equal steps and, assuming reversible heating, the first horizontal entropy step, which is equal to the heat content increase of one pound of water through the first heater in the condensate cycle divided by the absolute temperature of the source, is computed. Other steps are similarly computed, assuming in each case that there is no terminal temperature difference or that the feedwater is heated to the saturation temperature of the steam in that heater.

Final entropy of the exhaust steam at 79 deg. F. (1 in. Hg.) is thus obtained by proceeding in step fashion down the extraction curve PF. In this case the heat content of the steam to the throttle is 1381.1 B.t.u. and the heat extracted for feedwater heating is the sum of the heat quantities for the various heaters as shown by the rectangular steps on Fig. 1. The sum of these strips is equal to 383.3 B.t.u., the increase in heat content of the water from 79 deg. F. to 450 deg. F. Heat rejected to the condenser is area OABFG, approximately equal to (79 + 460) × (1.5431 — sum of entropy of extracted steam) = (539) × (1.5431 — 0.5155) = 554 B.t.u.

This approximation can be corrected by subtracting the heat in the small triangle ABB′ which is 0.5 × (79 — 32) × (0.0914) = 2 B.t.u. The heat rejected is therefore 552 B.t.u. The feedwater is heated to 450 deg. F. with a total heat content of 430.3 B.t.u. so the efficiency of the cycle, neglecting the feed pump which is less than 1 per cent is Eff. = (1381.1 — 383.3 — 552) ÷ (1381.1 — 430.3) = 46.7 per cent.

In the straight Rankine cycle the condenser loss would be area OABF′H approximately equal to (79 + 460) × (1.5431 — 0) = 831, this is also subject to the 2 B.t.u. correction and the efficiency would be Eff. = (1381.1 — 829) ÷ (1381.1 — 47) = 41.5 per cent.

If the extraction cycle efficiency be compared with this standard of reference, the improvement is (46.70 — 41.5) ÷ 41.5 = 12.5 per cent over the standard cycle.

Similar computations may be made using a different number of heaters or another final feed temperature assumed and the number of heaters varied. An interesting series of curves results and is shown in Fig. 2. It is apparent that if no preheating is done there will be no increase in economy. Further, if preheating is carried up to saturation temperature of the steam to the throttle, no work is done in the turbine by the extracted steam. In effect, live steam is used directly for feed heating, resulting in no economy. The curves for a definite number of heaters approach a maximum corresponding to greatest improvement, and it is further noted that with increasing number of extraction stages, the temperature corresponding to greatest improvement shifts towards higher temperatures ranging from 350 deg. F. with two stages to 470 deg. F. with eight stages of extraction. Again if we plot the maximum improvement versus number of stages we obtain the curve shown in Fig. 3.

The above curves have been obtained through purely thermodynamic considerations. No turbine has isentropic expansion but has increasing entropy with increasing expansion, and the vertical sides of the extraction steps would therefore be drawn parallel to the actual expansion curve. Heaters also operate with a pressure drop from the turbine to the heater and with terminal differences about which more will be said. Practically the relative magnitude of improvement per stage is approximately the same as for constant entropy expansion which involves less complication when complete studies are to be made.

The curve of per cent improvement against number of stages shown in Fig. 3 is of considerable importance as it shows at once the relative improvement per additional stage of feed heating. It is now possible to make

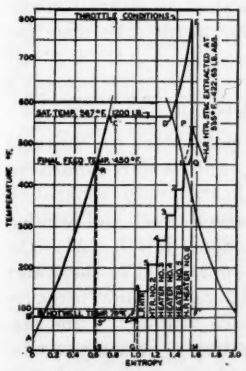


FIG. 1. THE TEMPERATURE-ENTROPY DIAGRAM SHOWING THE AREA UNDER THE CURVE PF EXTRACTED FOR FEEDWATER HEATING. THE HEAT EXHAUSTED TO THE CONDENSER IS THE AREA OABFG

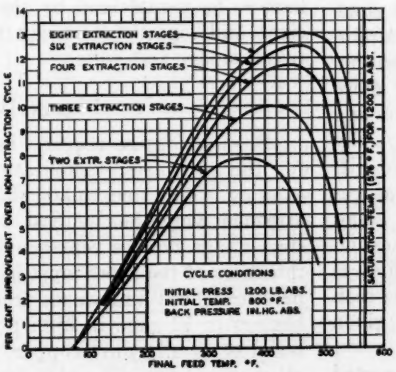


FIG. 2. THE GAIN IN EFFICIENCY DUE TO EXTRACTION IS A FUNCTION OF THE NUMBER OF HEATERS USED AND THE FINAL FEEDWATER TEMPERATURE. NOTICE HOW THE TEMPERTURE FOR MAXIMUM GAIN APPROACHES THE SATURATION TEMPERATURE AS THE NUMBER OF HEATERS, OR STAGES OF EXTRACTION, IS INCREASED

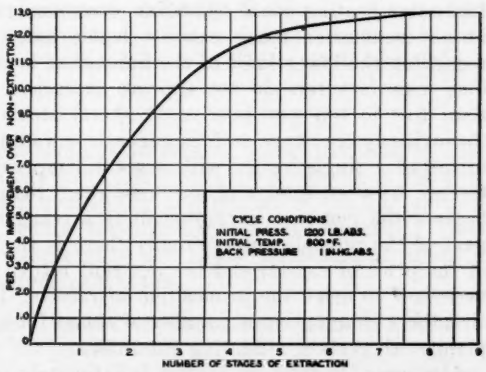

CYCLE CONDITIONS
INITIAL PRESS. 1200 LB.ABS.
INITIAL TEMP. 800 °F.
BACK PRESSURE 1 IN.HG.ABS.
PER CENT IMPROVEMENT OVER NON-EXTRACTION
NUMBER OF STAGES OF EXTRACTION

FIG. 3. AS THE NUMBER OF HEATERS INCREASES, THE INCREMENTAL GAIN IN EFFICIENCY BECOMES SMALLER. THE CURVE FLATTENS OUT AND EACH ADDITIONAL HEATER BECOMES OF LESS IMPORTANCE FROM AN EFFICIENCY STANDPOINT AND AT THE SAME TIME GREATLY INCREASES THE COST BECAUSE OF COMPLICATIONS IN THE PIPING LAYOUT, HEATER ARRANGEMENT AND FOUNDATION DESIGN

an economic balance between saving in turbine heat rate, and therefore reduced fuel consumption, and the various fixed and operating charges which are incurred with each additional heater added. Whereas the gain in efficiency is of the order of two per cent in increasing the number of heaters from two to three, the increase between seven and eight heaters amounts to only some two-tenths of one per cent and curve is becoming flat.

Factors which must be considered in the choice of the number of heaters depend upon individual plant conditions. The cost of coal or fuel used is important, as with higher coal cost the saving will be greater, but, on the other hand, the first cost of the heater is not the whole consideration. Piping, including valves, drainers, extraction lines and suitable bleed arrangements for extracting steam from the turbine, as well as pipe and heater insulation, amount to more than double the initial cost of the heater. The cost must also include labor of erection, so that by the time a heater is in place upon its supports a considerable investment has been made. It is also to be realized that as the number of heaters is increased, the piping becomes very complicated and maintenance is increased. When we consider the upper limit, it is necessary to determine if the feedwater heating could not be more economically done in an economizer using exhaust boiler gases. Again, regarding the lower limit of the number of heaters, turbine manufacturers do not approve extraction of more than five to ten per cent of the total steam passing through any one stage and, in general, it would not pay to install a single heater with a great temperature difference between inlet and exit feedwater temperatures because the per cent improvement is a relatively small part of the possible gain. Finally there is the question of the price of capital and the per cent return which is necessary to make the proposition attractive. It is seen that there is an optimum number of stages for any given plant with certain attending conditions.

Design of extraction heaters is intimately connected with the particular station arrangement that is to be employed. There are, however, certain principles common to all installations, such as determination of effective surface, physical design and materials to be employed. Manufacturers know from experience what surface is required to heat a given quantity of water per unit time a given amount with given steam conditions.

Resistance to Heat Transfer

As in the case of surface condensers, the overall coefficient of heat transfer is dependent upon three factors; the resistance of a condensing steam film, a tube resistance, and a water film all in series. Considerable research has been done on these film coefficients. Nusselt[1] has shown that for steam condensing on the outside of horizontal new tubes the steam film coefficient varies from 2500 to 3000 and is independent of water velocity through the tubes. However, Othmer[2] at the University of Michigan, showed that the presence of a very minute amount of air or non-condensable gases in the steam reduces the coefficient fifty per cent or more. It is, therefore, evident that proper venting of an extraction heater is of considerable importance.

Tube resistance is relatively very small. For brass the coefficient varies from 50 to 60 B.t.u. per sq. ft. per hr. per deg. F. difference per unit thickness, the latter being expressed in feet. For copper the coefficient is considerably higher, about 227, and the various copper alloys show coefficients not greatly different than those for brass.

When we come to the water film the work of Lawrence and Sherwood[3] stands out as an important contribution to an understanding of this resistance. The water film resistance is the dominating factor, being relatively much greater than the other two resistances. The tube resistance is so small relatively that increasing the conductivity coefficient of the tube material 100 per cent increases the overall heat transfer coefficient only some 5 to 10 per cent. If the overall coefficient be plotted against water velocity appearing in Lawrence and Sherwood's formula[3] a theoretical curve is obtained which agrees very well with test results on horizontal heaters. The effect of change in overall coefficient due to change in any other variable such as viscosity can also be predicted. Once the overall coefficient has been established the area required in the heater is the quotient obtained by dividing the total heat to be transferred by the product of overall coefficient and logarithmic mean temperature difference between steam and water.

Design Details

Physical design requires materials which are suitable for the pressures, temperatures, and water conditions existing. The steel plate shell heater with separately attached water box of cast or forged steel and welded steel flange nozzles represents modern design. Also the thickness of the tubes must be proportioned to the water pressures used and varies from 16 gage in low pressure heaters to 12 gage in high pressure heaters. Tube material is usually pure copper, admiralty, or some special alloy of copper. The older method of packing tubes at one end is not looked upon with as great favor as the method of rolling the tubes at both ends into the tube sheets. The tube sheet at the water box end is then held rigidly between the shell flange and the flange on the water box, while the tube sheet at the other end is made to a close clearance to the inside diameter of the shell and floats. In the case of vertical heaters U tubes rolled into the water box tube sheet make a satisfactory arrangement. Arrangement of steam baffles is an important feature to render all the tube surface equally effective, also tube support plates for long heaters.

To render the heater compact as well as to increase the heat transfer through increase in velocity of water circulation, more than one pass is customary, the usual number varying from two to six. Practice shows that a water velocity through the tubes of 4 to 10 ft. per sec. is economical resulting from a balance between the power lost in pumping the water through the heater with increased velocity as against the possible reduction of surface and other criterions of performance due to increased heat transfer rate. The designing engineer must check the number and location of nozzles to meet station arrangement as well as see that suitable bossed and tapped openings are provided for operating thermometers and pressure gages for observing water and steam conditions. Heaters should be pressure tested before acceptance both tubes and the shell.

[1] On Steam Film on Condensing Horizontal Tubes. Zeitschrift Ver. Deut. Ing., Vol. 57, 1913.
[2] One Effect of Pressure of Air on Steam Coefficient. Industrial Eng. Chemistry, Vol. 21, 1929.
[3] On Water Film. Industrial & Eng. Chemistry, Vol. 23, 1931.

Turbine Reliability From Operating Records

STUDY OF 346 TURBINES, ONE TO 18 YR. OF OPERATION, SHOW THAT TURBINE AND CONDENSER ACCOUNT FOR ABOUT ⅔ OF THE TOTAL OUTAGE

OPERATING DATA for 346 turbines with service records of from 1 to 18 yr. are presented in a recent report of the N.E.L.A. Average turbine data and performance factor for various lengths of service are shown graphically by Fig. 1 and outage factors for the units by Fig. 2.

Definitions applying to these two figures are as follows: Period hours,—total hours per year, 8,760 in the case of units more than 1 yr. in service and in the case of new turbines from the hour of initial operation to the end of the year; service demand availability factor,—the ratio of the service hours to the demand hours; unit capacity factor,—the ratio of the kilowatt hours generated to the product of the unit rating and the period hours; unit operation factor,—the ratio of the service hours to the period hours.

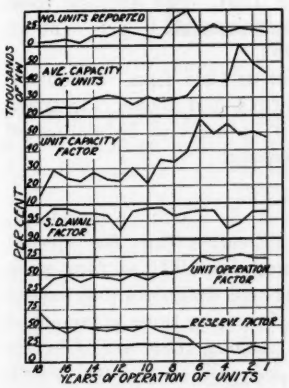


FIG. 1. AVERAGE TURBINE DATA AND PERFORMANCE FACTORS

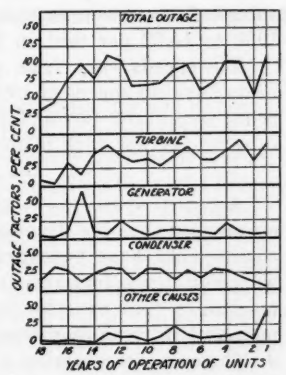


FIG. 2. OUTAGE FACTORS FOR VARYING YEARS OF SERVICE

Total outage of the units range between 7½ and 10 per cent, the outage time being subdivided, as shown by Fig. 2, between the turbine, the condenser, the generator and to other causes. An analysis of the turbine outage hours is given by Table I. This shows total hours, per cent of total, number of machines affected and the outage hours per machine for 14 subdivisions of the turbine proper. Similar analysis for generator outage is shown by Table II, for condenser outage by Table III, for other causes by Table IV.

In considering these data and in drawing conclusions from them, the fact should be kept in mind that data upon a considerable number of turbines over 20,000 kw. in capacity were not furnished in time to be included in this report. Had these data been available and included in the tables, certain of the factors would have been modified.

Due to decreased loads on the different plants, many of the figures and factors vary from those of the previous year. The rated capacity of the units reviewed in Table III increased in 1931 about 6.5 per cent over that in 1930, while the kilowatt hours generated increased only 2.5 per cent. This would indicate both an increasing reserve capacity and a decreasing unit capacity factor which decreased from 43.35 per cent in 1930 to 38.42 per cent in 1931. The actual demand hours show a decrease in 1931 from 1930 figures.

This suggests that hydro-electric power where available was used to the greatest possible economic extent with a resultant decreased demand for steam generated power. This is also indicated by the decrease in 1931 of the total service hours from those of 1930. As a consequence of these two decreases, idle hours and reserve hours increased in 1931. A result of these favorable operating conditions is the reduction of per cent total outage from 9.17 in 1930 to 8.37 in 1931. Due to this fact, turbines were obviously enabled to operate continuously for longer periods for the number of idle periods was reduced from 37,860 in 1930 to 34,024 in 1931.

OUTAGE ANALYSIS

Various average factors all show decreases in 1931 from the figures in 1930, with the exception of the service demand availability and maximum possible unit operation factors which show a small increase. These changes appear to be due to the influences discussed in the preceding paragraphs.

TABLE I. ANALYSIS OF TURBINE OUTAGE HOURS

	Total Hours	Per Cent of Total	Number of machines affected	Outage hrs. per machine affected
Steam Casings	1,401	1.14	51	27
Governors	2,285	1.86	111	21
Control Gear	6,661	5.44	155	43
Shaft Packings	4,687	3.81	59	79
Nozzles and diaphragms	1,327	1.08	7	185
Shaft	440	0.36	8	55
Wheels or spindle	4,913	4.01	18	270
Buckets or blades	16,551	13.51	51	324
Vibration	2,350	1.92	35	67
Bearings	1,911	1.56	67	28
Lubrication system	2,417	1.98	124	20
Cleaning oil system	2,933	2.39	104	28
Annual Inspection and Adjustment	70,158	57.22	184	381
Miscellaneous	4,561	3.72	106	43
Total for repairs and maintenance	122,595	100.00	-	-

TABLE II. ANALYSIS OF GENERATOR OUTAGE HOURS

	Total Hours	Per Cent of Total	Number of machines affected	Outage hrs. per machine affected
Vibration	560	2.03	19	29
Oil Leakage	129	0.47	11	11
Armature core	3,944	14.31	1	3,944
Armature windings	1,311	4.75	18	73
Field windings	5,233	18.98	39	134
Exciter	1,226	4.44	58	21
Annual inspection and cleaning	9,059	32.86	100	90
Miscellaneous	6,110	22.16	79	77
Total for repairs & maintenance	27,572	100.00	-	-

Analyses of outage hours are presented in Tables I, II, III and IV, while Fig. 2 shows the per cent outages for units of varying years of service. An outstanding figure in Table I on turbine outage is the increase of the per cent of outage due to buckets or blades. In 1930 this outage amounted to 8.72 per cent but in 1931 this had increased to 13.51 per cent, a proportionate increase of

*See Problems in Turbine Design by C. Richard Soderberg, Power Plant Engineering p. 526, July 1, 1932.

55 per cent. Such a large increase should lead to a further study of certain factors, such as high tip speeds, moisture at exhaust and blade erosion, which appear to be contributing factors to this increased outage.

Many of the other factors show somewhat smaller percentages than in 1930. The total hours for annual inspection decreased from 75,776 in 1930 to 70,158 in 1931, a decrease of about 7.5 per cent. This may be attributed to the extended use of the newer and better machines as well as to a gradual improvement in the construction and operation of all parts.

TABLE III. ANALYSIS OF CONDENSER OUTAGE HOURS

	Total Hours	Per Cent of Total	Number of machines affected	Outage hrs. per machine affected
Leakage	6,893	10.93	133	52
Cleaning	40,921	64.88	185	221
Tubes	7,323	11.61	62	118
Shell	525	0.83	34	15
Circulating pumps	3,659	5.80	92	40
Condensate pumps	755	1.20	49	15
Air pumps	873	1.38	67	13
Miscellaneous	2,123	3.37	61	34
Total for repairs & maintenance	63,072	100.00	-	-

TABLE IV. ANALYSIS OF OUTAGE HOURS DUE TO OTHER CAUSES

	Total Hours	Per Cent of Total	Number of machines affected	Outage hrs. per machine affected
General Piping	6,159	20.02	166	37
Boiler room	4,586	14.90	45	102
Plant electrical	5,634	18.30	114	49
Outside electrical	8,102	26.31	23	352
Miscellaneous	6,304	20.47	49	129
Total for repairs & maintenance	30,785	100.00	-	-

Generators

Percentages given in the analysis of generator outage hours presented in Table II are abnormally affected by the outage of one generator for 3944 hr., due to the armature core. If allowance is made for this one outage, it will be found that substantial reductions were made in the per cent outages for armature windings and field coils, but increases occur in those due to annual inspection and miscellaneous. A significant factor is the decrease in total hours of generator outage from 42,813 in 1930 to 27,572 in 1931, a proportionate decrease of 35.6 per cent.

In Table III on condenser outages, the per cent of total outage due to leakage and to tubes has increased over corresponding figures in 1930, while the per cent for cleaning has decreased. It is probable that the more extended use of chlorine in the circulating water had some influence on these results. Total outage hours due to the condenser decreased from 70,726 in 1930 to 63,072 in 1931, a decrease of about 11 per cent.

Outage hours due to other causes, as shown in Table IV, are contrary to the trends in the preceding tables and show an increase in total from 19,817 in 1930 to 30,785 in 1931, or 55 per cent. No one single cause seems to have contributed to this sizable increase.

Inspection period reports were received on 249 turbines which were inspected either in 1930 or 1931. Of these, 68 were inspected in 1930 only, 104 were inspected in 1931 only, while 77 were inspected in both 1930 and 1931. Of the remainder, 35 were not inspected either in 1930 or 1931. The remaining 50 units were reported as not having been inspected in 1931 but no mention was made of 1930 inspection, although undoubtedly these were inspected during that year. Insufficient data were furnished to enable a correct estimate to be made of the total length of the inspection period. Random figures indicated an average period of 10 to 14 da.

High Pressure Units

Data on the 12 high-pressure units indicate higher average unit capacity and unit operation factors than the average of the other 334 turbines. These machines are operated in preference to the less economical units on the same systems. Comparatively high turbine outages resulted in a lower average service demand availability factor than the average of the other 334 units. This outage is chargeable to certain units and is probably partly due to deposits on blading, a difficulty which has not been entirely overcome. Compared with 1930 figures, the performances of the high-pressure turbines show considerable improvement. The average unit capacity factor increased from 51.28 per cent in 1930 to 55.58 per cent in 1931. The average unit operation factor remained substantially the same. The average service demand availability factor increased from 82.68 per cent in 1930 to 88.78 per cent in 1931. The average total outage factor decreased from about 19.0 per cent in 1930 to 14.22 per cent in 1931.

Tip speeds vary from 660 to 1205 f.p.s. Seventeen units have tip speeds of 1000 f.p.s. and above. Tip speed is an important factor for it appears to be connected in some manner with blade erosion.

Awards from the Charles A. Coffin Foundation, established by the General Electric Co., for special achievement have been granted for 1932 to four shop workmen, three foremen, four tool designers and expert mechanics, four construction foremen, three commercial men and thirteen engineers. Among them are: Charles J. Thomson for erection of 3½ million dollars' worth of electrical equipment in the Russian Dnieprostroy installation, including five waterwheel generators, the largest of their kind, which ran smoothly from the start-up; Dr. Sanford A. Moss for the centrifugal supercharger for airplane engines, which runs at some 30,000 r.p.m., makes possible high-altitude, long-distance nonstop and high-speed flying, and adds 50 to 75 per cent to the power of the engines at sea-level; Herbert D. Brown for development of the mercury arc rectifier to replace bulky and expensive rotating equipment, largely used in connection with electric railroads; George B. Shanklin for improvements in high-voltage, oil-filled underground cable for voltages up to 132,000; Ernest L. Robinson and Walter C. Heckman for discovery of the cause of failure in medium sized steam-turbine buckets and design to overcome such failures; Gwilym F. Prideaux for an electric lamp to use in taking indoor photographs and movies.

In a series of investigations recently with a new form of carbon known as thermatomic carbon, it was found that by the use of this material in an electric induction furnace, bodies up to a few cubic feet in volume could be heated uniformly and that temperatures for vaporizing carbon were easily obtained. The light produced in this manner is just like sunlight. Granite rock is instantly vaporized in this furnace and wood vaporizes with explosive violence.

Part II. Equipment for Storing, Pumping, Heating, Distribution and Burning.

OIL FUEL FIRING *and* Combustion Equipment

By
E. G. Peterson*

SELECTION OF proper equipment for an oil firing installation requires that preliminary calculations and estimates be made to determine capacities of storage tanks, pumps, heaters, burners and pipe lines. To determine the economical oil storage capacity it is necessary to estimate daily plant consumption of fuel, generally expressed in gallons or barrels (of 42 U. S. gal. each) per day. For pump and heater sizes, the maximum plant consumption in gallons per minute and pounds per hour is required. For burner sizes, the maximum fuel consumption per boiler in pounds per hour should be known.

Plant or boiler capacities in terms of pounds of steam per hour or boiler horse power may be reduced to pounds of oil per hour or gallons of oil per minute as follows:

$$\text{Lb. of oil per hour} = \frac{100 \times \text{lb. steam per hr.} \times \text{B.t.u. absorbed per lb. of steam}}{\text{B.t.u. per lb. oil} \times \text{per cent efficiency}}$$

or,

$$\text{Lb. of oil per hour} = \frac{100 \times \text{Boiler Horsepower} \times 33{,}479}{\text{B.t.u. per lb. oil} \times \text{per cent efficiency}}$$

$$\text{Lb. of oil per hr.} \times 0.002 = \text{approximate gal. per min.}$$

Storage Tanks

Besides plant demand, a number of factors influence the selection of storage tanks; method of fuel oil delivery whether by tank wagon, tank car, barge or tanker, or by pipe line from nearby bulk storage tank and the reliability of such delivery service must be considered; capacity, shape and dimensions of tanks are sometimes subject to space limitations.

Generally tanks are built in cylindrical shapes and are made in stock sizes to meet various conditions of space limitations and capacity. Physical dimensions as well as capacity influence price. Square or rectangular tanks are sometimes required, though the greater weight of material per unit of volume and the necessity for stays or tie rods increase the cost of these shapes over the cylindrical tanks.

When purchasing tanks the number and size of openings, exclusive of manhole, should be specified. These openings should be for: Fill line; vent; top suction; bottom suction; circulating line; steam or hot water connection to internal heating coil; return connection from coil; level gage; stick or plumb line gage.

With reference to gage thickness of plate and type of heads and seams, tanks should be purchased to conform to underwriters' specifications or to local ordinances.

All pipe connections inside of tanks should be welded except where threaded into couplings extending through the shell of the tank. This applies especially to internal heating coils and their connections, as leakage of steam into the body of oil may result in boiling over of the tank.

Pump Equipment

In the selection of pumps, maximum plant capacity and the pressure required in the burner lines should be considered. Pump capacities are generally expressed in gallons per minute.

Pumps may be steam or motor-driven. Steam pumps may be direct-driven, duplex, piston or plunger type, or turbine-driven, screw or rotary type. In plants, where difficulty may be experienced in disposing of exhaust steam, it is good practice to provide a motor-driven screw, rotary, or piston pump for regular service with a steam-driven pump in reserve. In the case of plants employing all steam-driven auxiliaries and which may at times be required to start up from a cold condition, it is customary to provide a small motor-driven rotary pump of just sufficient capacity to raise steam for the operation of the auxiliaries. When current is not available for operation of a motor-driven pump, a small tank of light furnace oil may be provided, so constructed that pressure may be

*Peabody Engineering Corp., New York, N. Y.

applied to it by means of compressed air or carbon dioxide.

When piston pumps are employed, an air chamber of generous proportions should be provided to damp pressure fluctuations. All seams should be welded and connections made below the oil level to prevent leakage of air and consequent loss of cushioning effect. Piston pumps should be run at slow speeds for best results from the standpoints of operation and maintenance.

Oil Heaters

Two types of oil heaters are in general use; the straight tube and the coil types. Each type has its advantages and disadvantages. The coil heater generally is cheaper per square foot of heating surface and has no internal connections which could permit oil to leak into the heating steam. It is impossible to clean, however, except by chemical means, which have not yet been fully proven to be economical and practical. Straight tube heaters can be made in larger capacities than the coil type without introducing excessive pressure drop in the fuel oil system.

High-temperature steam is not recommended for the operation of fuel-oil heaters. A more expensive design of heater is required to take care of expansion; also excessive temperature contributes toward coking of the oil in the tubes.

Electric heaters are used in connection with low-capacity electric pumps for starting up when no steam is available and when using fuel oil requiring heating. Ordinarily these heaters are large enough to heat only 400 to 500 lb. of oil per hour and to increase the oil temperature about 100 deg. F.

Pump and heater sets are sometimes employed but are generally found to be more expensive than separate units connected on the job. Also it is difficult to obtain the combination of pump and heater to meet the fuel conditions. An air chamber is sometimes provided as part of the liquid end of the pump but it is necessarily of limited dimensions and quite ineffective in smoothing out pulsation.

Strainers are generally provided in the line between the tanks and pumps and in the line between heaters and burners. Pumps, heaters and strainers are often installed in duplicate to permit cleaning or repairs without interfering with the continuity of operation of the plant.

Piping and Valves

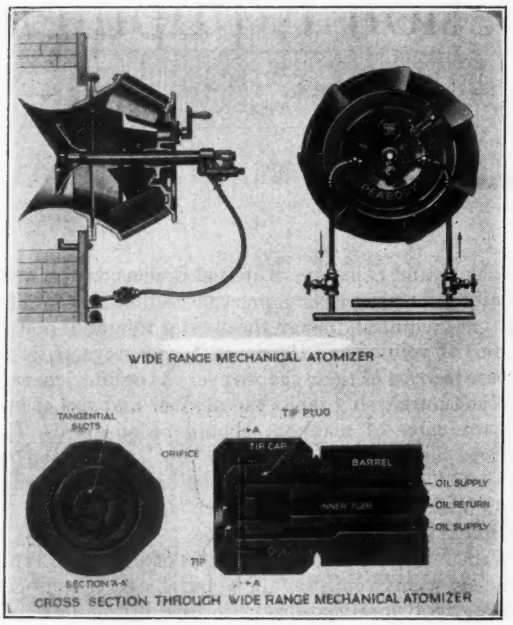
Piping, valves and fittings used in the installation of all equipment should be of the proper weight or pattern for the pressure employed, valves and gaskets being specified for oil service. For screwed joints, litharge and glycerine or proprietary compounds are employed. It is especially important that joints in the pump suction lines should be absolutely tight; also that the stem packing of new valves be inspected and packing replaced unless found in perfect condition. A suction line may be found tight under a pressure test, yet develop trouble when under suction, due to neglect of this precaution.

Valves in suction and pressure lines should be installed so that they are accessible to the operators. Gate valves are always recommended in suction lines, while either gate or globe valves may be used in pressure lines.

Relief valves are required for the protection of pumps and heaters. Pump relief valves are generally chosen one size smaller than the pump discharge connection and may return to the tank or directly to the pump suction line. Heater relief valves are usually ¾ or 1 in. size and return to the tank. Their function is not to relieve pressure of the piping system but to protect the heaters from excessive pressure caused by the formation of gas or the expansion of oil in the heater due to steam leakage when the oil side is out of service. These relief valves should therefore be set for pressures somewhat above the pressure in the system permitted by the setting of the pump relief valves or pump governor. The relief line to the tank must be free of valves or obstructions.

Measurements

Certain instruments are required as guides to proper operation of the auxiliary equipment. In their most sim-



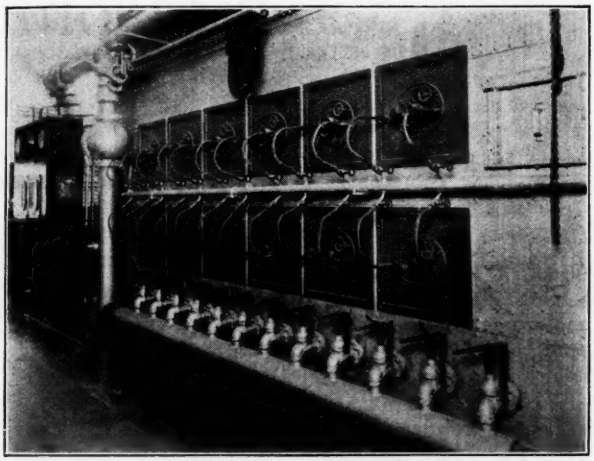


FIG. 1, AT LEFT. DETAILS OF WIDE RANGE MECHANICAL ATOMIZER BURNER.

FIG. 2, ABOVE. COMBINED GAS AND OIL BURNER INSTALLATION FOR PREHEATED AIR OPERATION.

ple form they consist of indicating pressure gages and thermometers, the latter of the industrial type with separable sockets. Pressures should be taken at the following points: Oil suction line (by compound gage); each pump discharge oil line; each heater, steam side; heater discharge oil header or before discharge strainer; oil line to burners just after discharge strainer. Temperatures should be taken at points on the oil suction line and at either the heater discharge or the oil line to burners.

Recording instruments may be provided to replace indicating gages or thermometers. Temperature controls on the oil heaters and tank coils are desirable. Pump governors which adjust the speed of steam pumps in proportion to the capacity demand are recommended for maintaining proper discharge pressure and are also effective in reducing steam consumption of the pumps.

Tank measurements of oil quantities may be made quite accurately by hand gaging or by means of several types of instruments which balance the weight of the column of oil in the tank by a column of liquid in a calibrated tube.

Mechanical Atomizing Burners

Burners for power boilers are of two general types, steam atomizing and mechanical atomizing. The steam atomizer may be designed for a flat flame, firing over a checkerwork floor or across a target wall, or it may give a round flame firing through an air register which mixes air with the oil spray before it enters the furnace. Steam atomizers may be of the inside mixing type, in which the steam and oil are brought together inside of the burner and mixed before expanding through the orifice, or of the outside mixing type in which the steam and oil come into contact with each other only after they have left the burner.

Mechanical pressure atomizers break the oil up into minute particles without the assistance of steam, air or other atomizing medium by passing the oil through passages at high velocities and directing these streams tangentially against the walls of a central chamber, generally conical with an orifice at the apex. Upon leaving the orifice the oil breaks up into small particles, the spray taking the form of a hollow cone.

Usual forms of mechanical atomizers, operating at 200 lb. per sq. in. pressure are limited in range, attaining a minimum capacity in the neighborhood of fifty per cent of the maximum for which they are designed. This capacity range (sometimes erroneously called "100 per cent load range") is obtained by reducing the supply pressure from 200 to 50 pounds per sq. in., the atomization becoming progressively coarser. This limited capacity range has been overcome in the design of the Wide Range Burner which maintains maximum flow to the burner at all capacities. returning to the tank or pump suction that portion of the total oil which is not burned. As the flow of oil through the passages is not reduced when the quantity sprayed is reduced, atomization can be satisfactorily operated over a wide range of capacity. Any number of burners may be controlled by means of a single valve. In this burner, the pressure—capacity curve is continuous, from maximum to minimum, which is desirable whether the control is by hand or automatic as there is a definite relationship between control pressure and capacity.

With the steam atomizer a portion of the steam generated by the boiler is consumed in the burner itself, which may run into a relatively large percentage of the boiler output through the carelessness or inattention of the fireman. This steam is discharged to atmosphere at the temperature of the stack gases, increasing the weight of the gases and thus increasing the stack loss.

Air Supply

Design of the air register used in conjunction with the atomizer, whether steam or mechanical, is of great importance in obtaining efficient operation on oil fuel. The air register should be capable of imparting a rotary motion of the air stream and the degree of rotation should be capable of variation by means of simultaneous adjustment of the vanes or doors in the register. Such a design of air register promotes rapid mixing of air and oil, producing a short flame with little excess air and permitting the application of oil burners to furnaces of limited dimensions. This type of air register and the wide range burner are shown in Fig. 1.

Air for combustion may be supplied by natural, induced, or forced draft. When forced draft is used, the air registers are enclosed in a windbox. Fans may be driven by engines, turbines, or motors, capacities of engine or turbine-driven fans being generally controlled by varying the speed. When such a fan supplies air to more than one boiler, each boiler should be fitted with a damper which can be properly controlled. Motor-driven fans are generally run at constant speed and air flow regulated by dampers.

When preheated air is supplied for combustion, the windbox and ducts should be insulated to reduce radiation losses and to prevent the firing aisle from becoming unduly hot. As the burner fronts comprise a large portion of windbox area, they should be suitably insulated. Figure 2 shows an installation of combined gas and oil burners operating on preheated air. The register front panels have built-in insulaton.

Oil burners may also be combined with burners to handle pulverized solid fuels and gaseous fuels. Such combined burners should be so designed that the various fuels may be burned with maximum efficiency and so that combustion air flows across all parts not in actual service, thus protecting those parts from damage by furnace heat. With this type of burner there is no loss in boiler efficiency caused by cooling of parts not in service as all cooling air is used for combustion. These burners should also be designed to permit instant changeover from one fuel to another.

Instruments should be provided to guide the fireman in the operation of the burners. These should include pressure gages to indicate the control pressures of the fuel, thermometers, draft gages, and damper operating mechanisms. These should be located close to the fuel control valve. Flow meters and stack pyrometers are also desirable. Automatic control may be applied to all boilers or to a group of boilers of sufficient capacity to take variations in plant load, while the remainder of the boilers are operating on base load.

If a man in Chicago could shout the local time so loud it could be heard around the earth, then, as his voice reached the various cities to the west of him, he would always be calling local time. This is because the velocity of sound is practically balanced by the speed of the earth's rotation at the latitude of Chicago.

POWER PLANT ENGINEERING April 1933

Demountable Walls for Power Plant Construction

R. B. HORNER, BYLLESBY ENG. & MGT. CORP., DISCUSSES NEW DEVELOPMENT BEFORE A MEETING OF COMPANY'S ENGINEERING DEPARTMENT.

AN APPRECIABLE PART of idle investment is in building space provided to house future equipment. This fact led us to study the types and materials of construction we have been using. The demountable aluminum wall construction was developed as a result of this study.

We believe that if a type of construction can be developed designed primarily for simplicity, and low cost in alteration, the first cost of which is relatively low, the durability and weather tightness of which is satisfactory, the necessity for providing idle space would be largely eliminated. We also believe that the aluminum clad building, designed to be demountable, meets these conditions to a large extent.

The one which we have been using for study consists of a hollow wall about 5 in. in thickness, the inner and outer surfaces of which are 18 ga. aluminum sheets. These are attached to and supported by an aluminum girt and stud system. This system is incorporated into the wall and is attached by brackets to the steel framework of the building. The girts and studs are also formed from aluminum sheets. The thermal insulating material, in this case a rock wool blanket, is attached to the girts and studs, between the inner and outer wall surfaces.

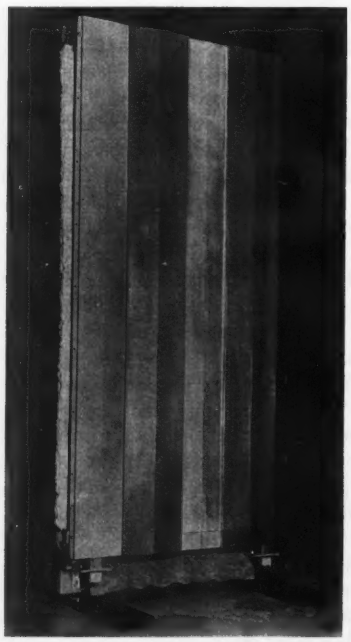


FIG. 1. EXTERIOR WALL SURFACE OF A DEMOUNTABLE WALL SECTION

Gray sheet as it comes from the roll was contemplated as it is the least costly finish obtainable. The exterior wall sheets are formed in such a way as to provide resistance to wind pressure and to provide weatherproof but readily demountable joints. Advantage is taken of these features to develop an architectural treatment which is based on a logical and natural use of material. The treatment can be made attractive and yet be extremely simple. Interior sheets are flat and are attached to the girts and studs by bolted battens of extruded material. The resulting interior appearance is a panelled wall surface.

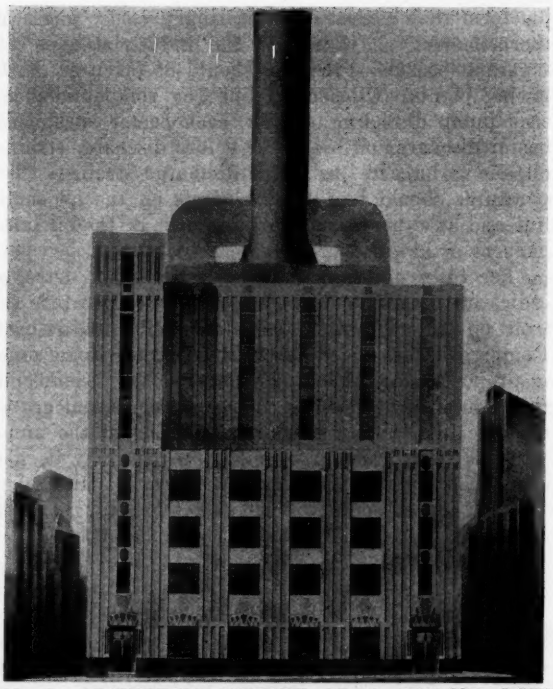


FIG. 2. ARCHITECT'S SKETCH OF A STATION USING ALUMINUM WALL CONSTRUCTION MADE TO SHOW THE SIMPLICITY OF THE DESIGN

Figure 2 is a photograph of the exterior side of one of these demountable aluminal wall panels. The thermal insulating material, placed in the interior of the wall, is mounted on expanded metal in sheets about 3 ft. 6 in. by 8 ft. The period required for erection should be very much reduced below that required for laying up masonry. Labor costs should be less; owing to the lightness of material, very little hoisting machinery would be required. The mixing and handling of material is eliminated while dismantling involves only loosening of bolts and removal of the sheets.

Alteration of an existing building is simplified as the design is a repetition of a few types of building units, each of which is interchangeable with others of its type. Excepting for a few special closing plates, loss of material due to alterations would be reduced to a minimum.

It appears that the demountable aluminum construction reduces the importance of those construction elements which might lead to idle investment in building space. It also seems to show decided advantages in alterations to existing buildings to allow for rearrangement or replacement of equipment. Studies of the initial cost of this demountable construction show a saving of 9.6 per cent in the overall cost of the building or 52 per cent in the cost of walls above grade.

Our investigation leads us to believe the demountable wall construction has practical possibilities. We are convinced that it will be durable and can be made weathertight by the use of proper insulating material yet loss through the walls can be reduced considerably below that of masonry wall construction.

Power Utilization

Agitator Power Consumption

RECENTLY a question arose in an industrial plant as to the power required to drive a stirrer for a large paste vat, 3½ ft. high by 4 ft. 7 in. diam., holding 375 gal. The stirrer to have four blades, 4 in. wide by 2 ft. long and run at 25 r.p.m.

Little data seemed available on the power requirement of agitators or mixers. Evidently, this depends primarily on the specific gravity and viscosity of the material, the viscosity being by far the more important. Tank size and shape, paddle design and speed are also important. Inquiry for information brought forth the following:

E. L. Kallander of the Chemical Research Dept., Dennison Mfg. Co., Framingham, Mass., reports:

Agitation of Adhesives

"In the manufacture of glue, mucilage and library paste, we have developed no definite method of calculating the power required for stirring. We usually determine this by trial and error, after following the recommendations of the equipment manufacturer.

"It is our practice to heat the batches of adhesive in order to promote thorough mixing and dissolving of the solid ingredients. We have made scattered measurements of the coefficient of viscosity, which I would list as follows: Glue, 1 to 20 poises; mucilage, 0.3 to 1.0 poise; paste, 0.010 to 15 poises.

"Viscosities in a batch of glue, for instance, vary widely over the period of stirring. For instance, when a batch is first stirred the viscosity is little more than that of water; namely 0.01 poise but on dissolving, the viscosity may build up, at a temperature of 200 deg. F. when the solution is complete, to approximately 2 poises. On cooling thence to room temperature, the viscosity may further increase to 15 or 20 poises."

Experiment Usually Best

From practical experience, most manufacturers can closely approximate power requirements and can, of course, give the power requirements of their equipment operating with water. The Pfaudler Co., Rochester, which uses an anchor shaped agitator at the bottom of the tank or three propellers on a vertical shaft, says:

"Two or three times the power required for water may be demanded for moderately viscous materials. For really heavy viscous materials, three or four times the power required for water should be used. It is seldom that a manufacturer is able to estimate accurately in advance the speed of agitation which would be most satisfactory for his product and also the resultant power required.

"Where a new product is involved it is impossible to determine the exact agitator speeds required and the horsepower requirements. It is our suggestion, in cases of this kind and where a motor drive is desired, that a pulley drive be supplied with the equipment at first. The purchaser can then use this until he is able to arrive at the proper agitator speed and horsepower requirements. We then furnish the proper motor drive with the proper speed ratio."

Test Data on Water and Oil

Data from the New England Tank & Tower Co. of Everett, Mass., are given below. These tests were made in test tanks, the one for water being 12 ft. in diameter and 6 ft. deep. Curves in Fig. 1 show variation of power consumption with the size and type of agitator. Curve 1 is the power required by a three blade paddle. Stirrers of this type are usually operated at low speeds from 35 r.p.m. for the small down to 8 r.p.m. for the larger units. At speeds of over 20 r.p.m. the power consumption of the one shown is high. They give mixing in horizontal strata with little agitation.

Curves 5, 4, 3, and 2 show the power requirements of 36, 42 and 48-in. Nett-Co. turbines. These agitators give a combination radial and rotary and vertical circulation and in conjunction with proper baffles give several distinct vertical and one horizontal planes of circulation. Curve 6 is for a 48-in. propeller type agitator. These are for higher speed operation than the turbine types, giving vertical circulation down the center and up at the sides or, for deep tanks, two opposed propellers may be used to give two zones of action.

It must be remembered that these curves give no indication of the agitation produced. The propeller appears to use less power than the turbines but at the same speed the 42-in. turbine will produce 50 per cent and the 48-in. turbine 100 per cent more agitation than the standard 48-in. propeller. To obtain the same agitation as given by the 48-in. turbines at 70 r.p.m. the 48-in. propeller would have to run at about 100 to 110 r.p.m.

At present no device will measure the degree of agitation; visual observation based on experience and judgment is the only guide. The entire mass may be set in motion without obtaining a great deal of actual mixing action or a violent agitation may be produced near the surface without greatly affecting the mass as a whole.

Power Varies with Viscosity

Curve 3 of Fig. 1 is the power consumption of a 42-in. turbine with a baffle ring in heavy asphaltic road oil with a viscosity of 62 poises at 68 deg. F. The tank had a cone bottom with dimensions as shown in the small sketch in Fig. 3, holding a batch of about 1100 gal. No vertical baffles were used in this test.

Further tests at two different speeds are shown on Fig. 2 as a function of temperature and viscosity. In this case, the tank had 4 vertical baffles as shown in the sketch, Fig. 3. The temperature rise was due to the energy input of the agitator. Variations in the temperature of this particular oil changed the viscosity as shown by Curve 1, Fig. 3. This concludes the data supplied by the N.E.T. & T. Co.; the following conclusions are by the editors.

When the power input is plotted against viscosity as

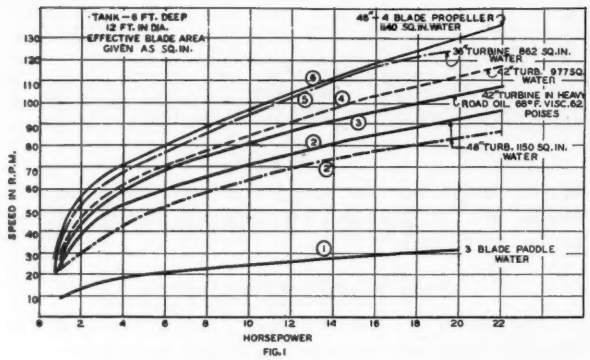

TANK—6 FT. DEEP
12 FT. IN DIA.
EFFECTIVE BLADE AREA GIVEN AS SQ. IN.
48"-4 BLADE PROPELLER 1140 SQ. IN. WATER
36" TURBINE 862 SQ. IN. WATER
42" TURB. 977 SQ. WATER
42" TURBINE IN HEAVY ROAD OIL 68° F. VISC. 62 POISES
48" TURB. 1150 SQ. IN. WATER
3 BLADE PADDLE WATER
SPEED IN R.P.M.
HORSEPOWER

FIG. 1

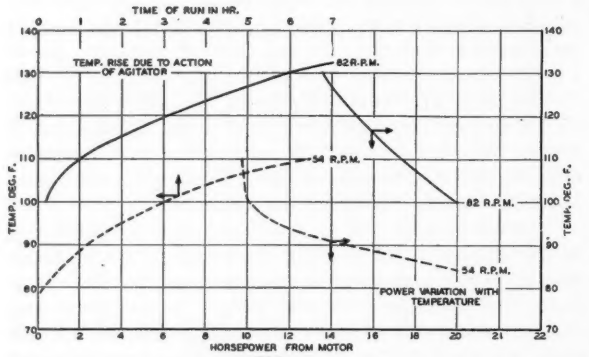


FIG. 2

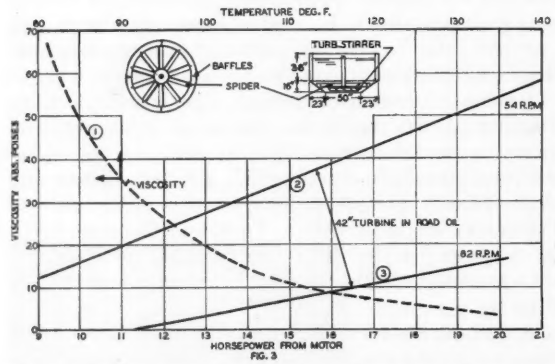


FIG. 3

FIG. 1. POWER FOR AGITATORS. TANK 6 FT. DEEP, 12 FT. DIAM. (1), 3-BLADE PADDLE IN WATER. (2), (2') TWO TESTS ON 48-IN. TURBINES IN WATER, 1150 SQ. IN. BLADE SURFACE. (3), 42-IN. TURBINE, 977 SQ. IN., IN HEAVY ROAD OIL, VISCOSITY 62 POISES AT 68 DEG. F. (4), 42-IN. TURBINE IN WATER. (5), 36-IN. TURBINE, 862 SQ. IN. IN WATER. ALL TURBINES WERE 10 BLADES. (6), 48-IN., 4-BLADE PROPELLER, 1140 SQ. IN. IN WATER

FIG. 2. POWER USED FOR STIRRING ROAD OIL AT VARIOUS TEMPERATURES, FOR 54 AND 82 R.P.M., OF 48-IN. TURBINE. BAFFLES AS SHOWN IN FIG. 3. VISCOSITY 67 POISES AT 81 DEG. F.

FIG. 3. A, ARRANGEMENT OF TURBINE AGITATOR AND BAFFLING. CURVE (1) VARIATION OF VISCOSITY OF ROAD OIL WITH TEMPERATURE. (2), (3) VARIATION OF POWER REQUIRED AT 54 AND 82 R.P.M. WITH VISCOSITY

shown by curves 2 and 3 of Fig. 3, the power consumption at constant speed is seen to be almost a linear function of the viscosity. Power consumptions at 82 r.p.m. are almost twice those required at 54 r.p.m. This is not substantiated by Curve 3 of Fig. 1, however, where no vertical baffles were used. Here the power at 54 r.p.m. is about 3.2 hp. and at 82 r.p.m. about 10.2 hp. or nearly treble instead of double as indicated by curves of Figs. 2 and 3. It is probable that the viscosity of the first test varied somewhat as the test progressed.

Although the entire problem might be subject to scientific analysis, it seems to be the opinion of those most interested in the subject that the time and expense of obtaining the necessary test data would not be justified.

It is probable that the paddle agitator in question would require less than 1 hp. input with water or 2 hp. with mucilage. This is a matter of experience, however, and the pulley drive previously referred to should be used.

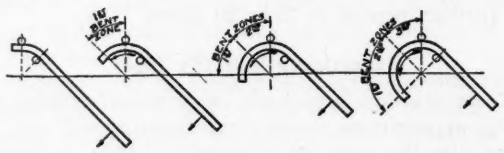
Undoubtedly many readers have agitators of different types and sizes used for a variety of materials. We shall be glad to receive data on this subject and will tabulate and publish it. Data should include the size, shape and capacity of tank, type, design, speed and dimensions of agitator, viscosity of material and power needed for driving.

Pipe Bending

Bending in Short Hitches Should Avoid Strain on the Part Already Bent

IN BENDING pipe, the metal is, of necessity, deformed from its original condition, fibers on the inside of the bend being somewhat compressed and those on the outside considerably elongated. Near the middle of the pipe as it bends, fibers are little changed in length. On the outside of the bend, there will be a slight flattening of the pipe, which reduces the stretching of the fibers but, if the pipe is sand-filled to prevent this flattening, the reduction in stretching will be prevented. For that reason a sand-filled bend should have a somewhat larger minimum bend diameter than one made with the pipe empty.

As the stretching occurs, the wall of the pipe will be thinned somewhat. This thinning is more as the bend diameter is decreased for a given diameter of pipe or as the pipe diameter is larger for a given bend diameter. There is also tendency for the stretch to be concentrated at the central portion of the bend, thinning the wall most at that point. Proper bend construction should distribute the stretch as much as possible and should never carry the stretching beyond a safe maximum.



For cold bends experience and practice of A. M. Byers Co. has set the center to center diameter of bend as 3.3 times the outside pipe diameter for genuine wrought iron bending pipe in small sizes, slightly more in large sizes. This gives the following:

Nominal Pipe Diam. In.	Minimum Diam. of Bend, In. Standard Pipe	Extra Heavy
⅜	2.2	2.2
½	2.8	2.8
¾	3.5	3.5
1	4.3	4.3
1¼	5.5	5.5
1½	7.0	6.2
2	11.0	9.2

For sand-filled bends, the minimum bend diameters should be somewhat increased. Hot bending permits of somewhat sharper bends, say bend diameters 2.6 times pipe diameter but requires special care and skill to avoid flattening and excessive thinning at the bend apex. It is, therefore best done by experts who have special facilities for the work.

Extra heavy pipe is advised for bending as the extra initial wall thickness gives a heavier wall after the stretching.

Successful bending requires that the stretch be applied successively to small sections or zones of the bend and that a stretched or bent zone be advanced out of the region to be affected by the next bending operation. Bending will be carried on as illustrated, the first bent zone being fed forward out of the bending device before the second bending, and so on. Quite often it is desirable to bend in more than four zones, especially for large pipe and large diameter bends.

Special wrought iron bending pipe is now available on the market, one particular application being for bending into coils for refrigeration work where resistance to corrosion is particularly desirable. By using short radius bends, the joining of straight lengths of pipe to cast bends is avoided, reducing the number of joints and the tendency to corrosion.

Refrigeration in the Modern Brewery

BASIC BREWING METHODS DEPEND UPON THE PROPER CONTROL OF TEMPERATURE WHICH IS MADE POSSIBLE BY REFRIGERATING MACHINERY. BY FRED OPHULS*

MANY BREWING PROCESSES are in use today, all of them derived from the basic system which in some breweries is used today. Changes made in the original brewing process, have been to save time in the manufacture of the beer and money in the investment needed for the equipment. Whether or not this has led to an improvement in the quality of the product is doubtful. Basic brewing methods, omitting the preparation of the malt from barley, can be briefly described as follows:

1. The malt is cleaned and ground to as fine a grist as possible.

2. The grist is run into the mash tub where it is mixed with hot water at temperature of about 155 deg. F. and is soaked here for a certain time and stirred during this process.

3. When rice and other cereals are used these are first cooked in the cooker and then mixed with the mash in the mash tub.

4. The liquid is then strained from the mash tub and run into the brew kettle, additional water being added in the mash tub to remove all the soluble substances from the residue.

5. The liquor is cooked in the brew kettle until it is of the desired density. The hops are introduced in the kettle and boiled with the liquor.

6. The liquor from the kettle, now called wort, is pumped to a collecting and settling tank above the beer cooler room.

7. From there it runs over or through the wort coolers and is cooled by water and refrigeration to a temperature of between 43 to 45 deg. F.

8. The wort so cooled then flows into the fermenting tubs where yeast is added and the process of fermentation started. Fermentation is continued for approximately from 5 to 7 da.

9. After this period the beer flows into the stock cellars where an additional secondary fermentation takes place under pressure so that a sufficient quantity of carbon dioxide is retained in the finished product. The beer is stored in the stock cellars 1½ mo. or more and is drawn off as required into kegs or bottles for shipping purposes. If beer is bottled it is pasteurized in bottles and this process precludes the necessity for further refrigeration for shipment and storage.

As above stated, this is only one and probably one of the original brewing methods used. The clarification of the beer which takes place in the stock cellars can also be done by artificial methods which reduces the time required for the finished product materially and therefore the capacity of the stock cellars in proportion.

REFRIGERATION

Refrigeration is required in the brewery for the following purposes:

1. Preserving the hops in their storage room.

2. Cooling the wort from the lowest temperature to which it can be cooled by the available water supply to 43 deg. F.

3. Absorbing the heat of fermentation.

4. Cooling the beer from the temperature at which it leaves the fermenting tubs, approximately 45 deg. F., to the temperature maintained in the stock cellars, about 34 deg. F.

5. To offset the heat leakage into the hop storage, fermenting cellar, stock cellars, racking off cellar, and keg storage.

6. When beer is bottled, the beer receptacle on the bottle filling machine must be refrigerated as well as sometimes the beer pipe bringing the beer from the cellars to the bottling machines.

7. To offset heat given up by the men working in the various refrigerated spaces, by the lights in these spaces, by the water used for cleaning and by the heat introduced by the opening of doors leading to non-refrigerated spaces.

It is not necessary to go into the calculations to determine the heat leakage into the various refrigerated spaces here because the method used is well known. When it is necessary to find the heat leakage through the walls and floors of old brewery buildings it must be remembered that most of them have no insulation in the modern sense of the word. The walls are generally built up of brick with a 1 to 2-in. space in the center mostly filled with pitch. The heat leakage through these walls is naturally greater than through brick or concrete walls insulated with 4 to 5 in. of pure sheet cork or its equivalent. Floors are not insulated either but

*Fred Ophuls & Associates, Inc., New York, N. Y. From a paper presented before the A.S.R.E.

instead are generally quite thick to make up to some extent for the lack of proper insulation.

Allowances for the refrigerating effect required to offset the heat produced by men working in refrigerated spaces, by lights, by wash water and opening of doors are also readily calculated. The determination of the heat to be removed in the cooling of wort and during the fermenting process deserves going into to some extent here.

Wort Cooling

Wort coming from the brew kettle has a temperature of about 212 deg. F. In this country this hot wort is not usually allowed to cool in a cooling pan exposed to the atmosphere as is customary in Europe, but is pumped directly from the brew kettle, after being strained in the hop jack, to the wort coolers. These coolers are of two types: the open air, Baudelot type or the double pipe, Dickeboch type. Both types of coolers have a water section and an ammonia or brine section. Economy in the use of refrigeration requires that as much as possible of the heat in the wort is removed in the water section. Where cold well water is available, this is used and the cooling surface so proportioned that the wort leaves the water section with a temperature not more than from 5 to 10 deg. F. higher than the initial temperature of the water and the same temperature difference should be allowed between wort coming on and the water flowing away from it.

When well water is used for beer making the hot well water from the wort cooler is discharged into a hot water storage tank at the top of the brewhouse. When city water is used for brewing the first cooling of the wort is done with it and sometimes a second water cooling section added in which well water if available is used when it is colder than the city water. The well water if not suitable for beer making is discharged into another hot water storage tank and is used for washing and cleaning purposes.

Final cooling of the wort is obtained either by ammonia or brine, mostly the former. The wort is cooled to from 40 to 45 deg. F., the temperature at which it is fermented. The heat transfer coefficient of the Baudelot type of cooler is generally taken at 80 and for the Dickeboch coolers between 100 and 150 B.t.u. depending on the relative velocity of the wort and the water in the refrigerating section. From the brewmasters point of view, it is desirable to cool the wort in the shortest possible time. To keep the investment in power and refrigerating plant at a reasonable figure the beer cooling period is generally taken at from 3 to 4 hr. per brew.

Wort after being chilled to 43 to 45 deg. F. is discharged into the fermenting vats, where yeast is introduced, and the fermentation started. The greater part of the solids dissolved in the wort is malt sugar. Fermentation is carried on until the beer has attained a certain predetermined alcoholic content which can be determined by observing the strength of the liquor from time to time by the use of the Balling** saccharimeter.

Information required to determine the heat evolved during the fermentation process is:

1. Brewing method to be used in plant.
2. Per cent Balling of wort to fermenting cellar or the equivalent weight of maltose per barrel.
3. Per cent Balling of beer leaving fermenting cellar or the equivalent weight of maltose per barrel.
4. If the secondary fermentation is used, the per cent of young beer in terms of the total amount of wort brewed daily.
5. The number of days beer is brewed per week.

Removal of the heat of fermentation is obtained in two ways. Where wooden fermenting vats are used the required amount of cooling pipes is suspended in the vat. Cold clean water is used in these pipes so that if any leakage occurs the beer is not contaminated. This water is recirculated and recooled in any suitable manner and this cold water circulating system is called attemperator system. When metal vats and tanks are used the attemperator system is not used. The surface of the exposed outer shell of those vats is sufficient to carry off the heat of fermentation into the air circulating in the cellar.

Since the wort is usually fermented at a temperature of from 43 to 45 deg. F. and the stock cellars are maintained at about 34 deg. F., it is customary to interpose a double pipe cooler in the pipe line bringing the beer from the fermenting cellar to the stock cellars. The refrigeration required at this point is determined in similar manner to that required in the beer cooler. When the beer before being drawn off into kegs or when bottled is first filtered and artificially carbonated, it is chilled once more in a double pipe cooler. The refrigerating effect needed at this point is comparatively small and does not exceed the work necessary to reduce the daily brew 2 deg. F. in temperature.

Storage

For maintaining the desired temperatures in the hop storage, fermenting and stock cellars and racking off room direct expansion or brine piping placed in these spaces has been used heretofore in this country. Experience obtained from plants previously installed in most cases determined the amount of heat absorbing piping needed in each space. For this reason it is desirable to calculate as accurately as possible the refrigerating effect required at each point and also ascertain the temperature levels at which the heat must be removed. It is then a question of the size of the brewery whether or not a multiple back pressure system will save sufficient fuel to warrant its installation. In relatively small breweries operated on the direct ammonia system it is customary to shut off the refrigeration entirely from all cellars, etc. when cooling beer and use the refrigerating machine or machines on beer cooling at high back pressure for that period only.

During the last decade some new breweries erected in Europe or plants that have been remodelled there have discarded the heat absorbing piping system in the hop storage, fermenting and stock cellars and racking off room and substituted a cold air circulating system. The chief advantages of this system are that any outside air that must be introduced into the refrigerated spaces can be purified to minimize the danger of contamination of the beer in process and that it eliminates the nuisance of defrosting and dripping of the pipe coils. Cleanliness in the manufacture of beer is of prime importance since foreign organisms getting into the wort or beer may spoil it.

Proper prime movers for the refrigerating machines and electric generating sets are steam engines and turbines. Large quantities of hot water are required for preparing the wort and for washing kettles and mash

**A specific gravity scale in which x deg. Balling is equivalent to 200 ÷ (200 ± x) specific gravity at 17.5 deg. C.

tubs. The water for this purpose is heated by 3 lb. exhaust from some of the steam driven units. For cooking purposes steam at from 20 to 30 lb. pressure is required. For grains drying if done at the plant steam at about 100 lb. pressure is used but I believe that the latest types of dryers use steam at a pressure considerably less than this. All the condensate from hot water heating coils, cooking jackets and pipe coils and grains dryer coils, is collected and returned to the boilers.

No matter what the size of the plant is to be, a heat balance should be prepared to show the relation between steam required for process and power requirements. Then based on this heat balance the boiler pressure to be used and the type of steam units to be installed must be chosen. What refinements in power plant equipment are permissible in each case depends on the output of the brewery, whether or not it has its own malting plant, ice making system, grains drying plant and available cooling water supply.

Examples of the important variation in heat balance requirements in brewing plants follow. In one large brewery rehabilitated in 1926, we installed condensing turbines. Fuel cost on a unit basis was reduced sufficiently to permit the operation of a 600 t. ice plant and the brewery combined for approximately the same total fuel cost which had previously applied to the brewery alone. In another large brewery rehabilitated in 1930 we installed bleeder type turbines and high pressure boiler and thereby effected a reduction in operating expense sufficient to bring a return of 22 per cent on the investment. These two installations, although of vastly different types, both proved to be profitable on account of the difference in the heat balance of the respective plants.

Low Turbine Leaving Loss Not Always Best

DISCUSSION OF THIS IMPORTANT POINT IN N.E.L.A. REPORT SHOWS AVERAGE LOSS ABOUT 4 PER CENT

LEAVING LOSSES, either in B.t.u. per lb. or in per cent of the adiabatic heat drop, are a measure of the unutilized energy in the steam to the condenser. These losses will be high in large capacity, single-cylinder turbines which operate at high vacuum, particularly where the limiting output of a given casing is approached. There has been a tendency in recent years to increase the ratings of given turbine casings. This increase in output makes it necessary to pass so much greater volumes of steam through the lost row of blades that even with the maximum permissible blade lengths, the velocity leaving the blades becomes excessively high.

Leaving losses, equivalent to the energy in the leaving velocity, thus increase rapidly as the limiting output of the casing is approached. When turbines are designed with a most efficient load at a relatively low per cent of the full rated capacity with the intention of operating a greater part of the time at most efficient load and of using full capacity for peak load or in emergencies only, the leaving losses at full-rated load will be quite high. Since steam volumes at 28 in. vacuum are approximately half those at 29 in. vacuum, turbines operating at the lower vacuum will have considerably lower leaving losses than those at 29 in. The use of double flow low-pressure turbines or of a double set of exhaust blades reduces the steam volumes through such set of blades and thereby reduces leaving losses.

The economic significance of leaving losses is not well understood by many engineers and little data are available on the leaving losses of turbines now in use. It is not to be assumed that low leaving losses are an index of high economic efficiency except under certain unusual conditions, such as extremely high fuel costs. Low leaving losses may indicate that the casing purchased is too large and expensive for the output desired. On the other hand, high leaving losses generally indicate that the given casing is being used for an output approaching its maximum capacity. This permits the use of a smaller and cheaper casing than would otherwise be necessary. The justification of the use of this smaller casing is dependent upon the economics of the particular system in question. The saving in fixed charges due to the cheaper turbine must be balanced against the extra fuel costs resulting from the increased leaving losses. Little data are available on the relations existing between savings in fixed charges and fuel costs from increased leaving losses. This relationship deserves further study by engineers.

There are certain cases where high leaving losses may be justified, as, for instance, in peak load units and standby turbines for emergency use. This economic problem is closely tied up with the useful life of the turbine and its average use factor during that life. Present data indicate a definite trend toward the early relegation of the older units to peak load and low use factor service and the favoring of the newer units with base loads. Furthermore, a definite trend toward the use of larger and more efficient turbines as well as the employment of increased steam pressures and temperatures. These factors must all be considered in placing an economic value upon leaving losses.

Data show that the leaving losses at most efficient load vary over a considerable range, from 0.91 to 3.96 per cent, with an average value of about 2 per cent. The leaving losses at full load appear to vary from 1.5 to 7.4 per cent with an average value of about 4 per cent. European engineers appear to favor lower leaving losses as is indicated by C. D. Gibb's statement in his recent paper:

"Modern standards of efficiency in this country (England) demand a leaving loss at most economical load not exceeding 3 per cent while financial considerations seldom allow it to be less than 1 per cent."

NEW WATER power brought under development in Canada during 1932 amounted to 378,923 hp. according to information received by the natural resources department of the Canadian National Railways. The addition of these new developments brings the water power installation of the Dominion up to 7,045,260 hp. No new works of any importance were undertaken during the year because of business conditions, the development being confined to the completion or continuance of projects that were in hand prior to 1932. The increase was due chiefly to the Beauharnois development near Montreal in Quebec; the Chats Falls plant on the Ontario-Quebec boundary and the Corra Linn development on the Kootenay River in British Columbia.

POWER PLANT ENGINEERING April 1933

This thing called POWER FACTOR—

Part VI. Effect of load on an induction motor upon power factor. Use of vector diagrams to show only induction motor load affects power factor calculations.

HELLO, OLD TIMER, what's wrong with your boiler plant, have you stopped running it—the steam pressure gages in the still room think there is a famine; they——"

"Oh yeah?" The chief engineer interrupted Val before he could go on further. "Have you ever thought of closing a steam valve in your department sometime, or of evening up the load factor? Our boilers have been working at 300 per cent all morning and 70 per cent of the output is going to your department. Say——"

"Now tut tut and a couple of more tuts," admonished the young chemist, leisurely hanging his hat on the rack and sitting down opposite the chief's desk. "Don't get excited—I'm not in here to discuss steam pressure. We've got that all straightened out. What I would converse with you about concerns matters of power factor, phase displacement, reactive components and similar highbrow matters."

"Indeed!" sneered the chief. "How interesting. Did it ever occur to you that you might be a confounded nuisance and as I have implied before, that I might have other things to do beside acting as tutor to a half-baked chemist?"

The chief's remarks did not disturb Val in the least. He sat and smiled at the engineer's feigned indignation. He knew the old man's wrath was all for effect.

"Well," he said finally, when the engineer quieted down, "you could do worse and anyway it's good for you. Didn't you tell me yourself that the only way to learn a thing was to try to teach it to somebody else? Well, I'm giving you a chance. But let's be serious, I want to know just how to go about actually figuring power factor. I understand pretty well what happens in the circuit, how a condenser has an effect just opposite to that of inductance, but how does one determine how large a condenser to install to improve the power factor a definite amount?"

"Is that all?" inquired the engineer, sharpening his pencil. "Wouldn't you like to know something about the single tax or the theory of least squares? However, I suppose I'm the goat, so let's get started. You want to know how to figure power factor, is that it?"

"Yeah," said the chemist, "and also, why does the load on an inductance motor affect power factor? I've read a number of times that induction motors running at low loads result in low power factor but none of those guys that write articles ever explain why. Why is it?"

"Now wait, one thing at a time. I'll try to explain some of those things. Perhaps I'd better answer your question about the induction motor first."

"That's the idea," exclaimed Val, "shoot!"

"To begin with, you must keep definitely in mind the fact that the displacement between the current and voltage in an alternating current circuit caused by the presence of inductance is such that the current *lags* behind the voltage—that we discussed in connection with the flywheel and also in considering the growth of current in an inductance circuit. In such a circuit, before the current can rise to its maximum value, a magnetic field must be built up surrounding the inductance. As a result, the current lags behind the impressed voltage. You understand that, don't you?"

"Yes," said Val. "You explained that in one of our earlier talks when I asked you why the induction and energy components were at right angles."[1]

"All right. Now an induction motor, as you know, consists of a stator winding connected to an external source of power supply and a rotor which is *not* connected to a source of e.m.f. When an e.m.f. is impressed across the stator winding, a revolving magnetic field is set up which induces currents in the rotor conductors. The stator winding, furthermore, is a highly inductive winding so when an e.m.f. is impressed across it the current which flows in the circuit lags behind the impressed e.m.f.

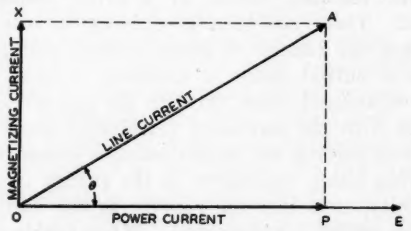


FIG. 1. VECTOR DIAGRAM SHOWING COMPONENTS OF THE LINE CURRENT

"Now, suppose we represent the impressed voltage by the horizontal line OE in this diagram (Fig. 1) and the line current by the line OA. Assuming a clockwise rotation of these vectors, the line current you see lags behind the impressed e.m.f. by an amount expressed by the angle Θ. From our previous discussion, however,

[1] p. 766 November, 1932 issue.

we know that the line current as shown here can be thought of as being the result of two components, a power component, OP, in phase with the impressed e.m.f. and an induction component, OX, at right angles to the power component. The induction component is known as the magnetizing component or simply the magnetizing current."

"The power component OP represents actual work done in the circuit, doesn't it?" interrupted Val.

"Yes, that's correct. The diagram I have drawn here represents the condition for an induction motor operating under load. Now before I go any further, I want to explain that the magnetizing component remains practically the same at all loads on the induction motor, that is, it takes about the same current to maintain the revolving field, regardless of whether the motor is carrying load or not. The angle Θ, of course, represents the power factor, indeed the cosine of this angle *is* the power factor.

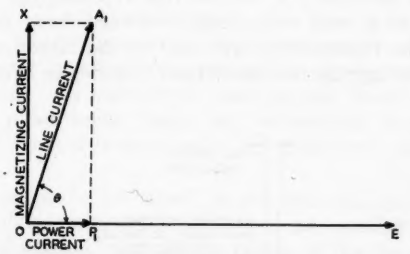


FIG. 2. EFFECT OF UNDERLOADED INDUCTION MOTOR ON POWER FACTOR

"Suppose now that we decrease the load on the motor so as to reduce the power component to OP_1, in Fig. 2. What happens? Well, as I told you, the magnetizing current remains essentially constant at all loads with normally applied voltage, so the length of the magnetizing component remains the same as it was in the first instance. Having OP_1 and OX we can draw the line current OA_1 since this is the resultant of the power component and the induction component. See?"

"Hot dog! Say, Chief, that's great," exclaimed Val enthusiastically, "I see what happens. The line current has decreased somewhat but the phase displacement between the line current and the impressed e.m.f. is much greater than before."

"That's right,—you get the idea. You see the power factor has decreased."

"Decreased?" echoed Val.

"Yes, decreased," repeated the Chief. "Remember, the power factor is expressed in terms of the *cosine of the angle of displacement*, not as the angle, and if you will look at your trigonometric tables you will see that as the value of the angle increases, the cosine decreases."

"Oh, to be sure, of course," said Val. "I knew that."

"Well, there you have it in a nut shell. Now you know the reason for the low power factor of induction motors at fractional loads. In the case of an induction motor operating at no load, the power current is just sufficient to supply the friction and windage losses, so that the phase angle between the line current and applied voltage is large and the power factor low. Understand?"

"I sure do" said Val emphatically. "That's fine."

"All right, now how do we correct or improve power factor? That's our next problem. Well, let's look at it this way. What do we have to do to Fig. 1 or Fig. 2 to decrease the length of OX, that is the magnetizing component? Suppose we add a reactive component which acts to oppose or neutralize the magnetizing component due to induction, in other words, suppose we add a vector OX below OP displaced exactly 180 deg. from OX (Fig. 3). Now let us add OY and OA vectorially so as to get OB. OB in turn may be considered as the resultant of OP and OZ. Do you follow me?"

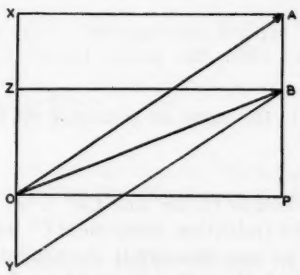


FIG. 3. DIAGRAM SHOWING NEUTRALIZING EFFECT OF CAPACITY REACTANCE UPON INDUCTIVE REACTANCE

"Yes" said Val, "I get yuh—by adding OY to OX vectorially you have decreased the length of OX to a new value OZ. Isn't that it?"

"Exactly" replied the engineer. "And this indicates the direction in which the solution of our problem lies. From our flywheel analogies and our study of the effects of inductance and capacity we know that a condenser will supply just such a reactive effect as is represented by OY. That is, a condenser acts to neutralize the effect of inductance.

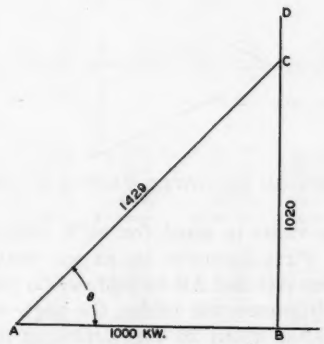


FIG. 4. DIAGRAM SHOWING VALUES OF REACTIVE CURRENT, LINE CURRENT AND POWER CURRENT

"Suppose then we have an industrial plant having a load of 1000 kw. at say 0.7 power factor and that it is desired by the installation of condensers to raise this power factor to 0.9 without changing the kilowatt load. This 1000 kw. load is represented by the horizontal line AB (Fig. 4) drawn to scale. This, of course, is the power component. To find the actual line current, we can do either of two things, we can calculate it from the relation kv.a. $= \frac{\text{kw}}{\text{p.f.}}$ or we can determine the phase angle between the power component (which is in phase with the applied e.m.f.) from trigonometric tables. Since the power factor is 0.7, we find this to be the cosine of the angle 45 deg.

"So, all that is necessary is to draw the line AC at 45 deg. to AB, its length being determined by the point C where it intersects BD, drawn upward from the point B. If we scale this length (AC) we find its value to be 1429 kv.a."

"Would the formula you mentioned give the same value?" asked Val.

"You mean kv.a. $= \frac{\text{kw}}{\text{p.f.}}$?" asked the engineer.

"Yes."

"Exactly" replied the engineer. "Figure it out for yourself, kw = 1000, the power factor 0.7. Therefore $\frac{1000}{0.7} = 1428.57$, the same as obtained by the graphical method."

"Does the length of the line CB (Fig. 4) represent the value of the induction component?" asked Val.

"Yes, and we can measure it or calculate it from the known values of the other two sides of the triangle. That is

$$CB = \sqrt{(AC^2 - AB^2)}$$

or putting it this way,

$$\text{Reactive kv.a.} = \sqrt{(\text{kv.a.}^2 - \text{kw.}^2)}$$

This comes out

$$\sqrt{(1429^2 - 1000^2)} = \sqrt{1{,}042{,}041} = 1020 \text{ kv.a.}"$$

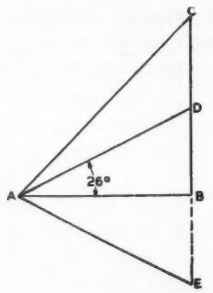


FIG. 5. CORRECTION OF POWER FACTOR BY CONDENSER

"Keep this value in mind for we'll come back to it in a moment. First, however, let us see what the angle must be between AC and AB to represent a power factor of 0.9. From trigonometric tables, the angle corresponding to cosine 0.9 is about 26 deg. Drawing the line AD (Fig. 5) at this angle and measuring the value of the vertical line DB we find that this corresponds to 485 reactive kv.a. See?"

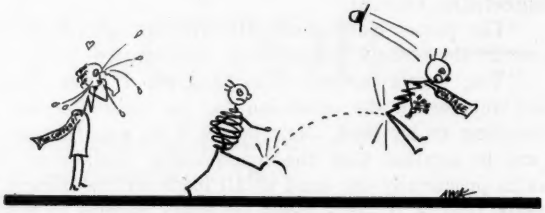
"Yes," said Val. "That is the magnetizing component for a power factor of 0.9, isn't it?"

"Correct, and remember this is 'lagging' reactive kv.a. To reduce the 1020 lagging reactive kv.a. we had with 0.7 power factor, therefore, we must supply 'leading' reactive kv.a. to the extent of 1020 — 485 = 535 kv.a. In other words, we must supply leading reactive kv.a. to exactly neutralize the lagging current represented by CD. So, to show this on the diagram, we draw BE below AB, exactly equal to CD.

"So you see, we have to add a condenser of 535 kv.a. capacity to this system to improve the power factor to 0.9. Is that all clear?"

"Yes, I think so," said Val. "Doesn't the condenser add any power load to the system at all?"

"Practically none" explained the engineer. "Capacitors, that is static condensers, and synchronous condensers, draw only leading reactive kv.a. from the line. The actual power load is so small (Fig. 6) that it is negligible in the solution of power factor problems. The



vector representing the capacitor or synchronous condenser is essentially a vertical line representing leading reactive kv.a. and extending downward from the horizontal line representing kw., and in the direction opposite to the lagging reactive kv.a. of inductive equipment.

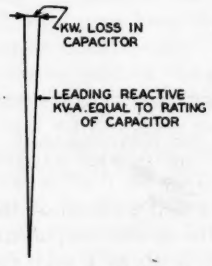


FIG. 6. VECTOR DIAGRAM OF CAPACITOR

"In this way then, you see, it is a simple matter to calculate the size of a condenser to correct any power factor condition you may have. Here, I'll draw the whole thing out and put the values down so you can easily see them (Fig. 7). Clear?"

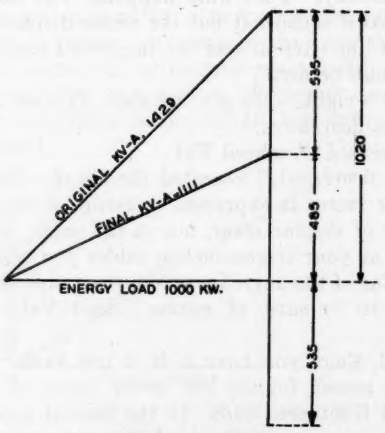


FIG. 7. DIAGRAM SHOWING SOLUTION OF POWER FACTOR PROBLEM

"Yes," replied the chemist enthusiastically, "it is quite simple when you know how. Of course, I had seen these diagrams, or some like them, before, and while I realized they were not difficult to follow, what

I really wanted to know was, how this thing called power factor worked—what it meant in the circuit and just why by doing certain things you could control it or correct it. Ed, the electrician, had told me that capacitors or synchronous motors or condensers would help but he never could explain just why."

"You feel sure you know now?" asked the chief, smilingly.

"Well, perhaps I could not explain it to anybody else as you have done to me, but I feel that I know something of what it is all about. I can quite easily conceive of this magnetizing current surging back and forth between the magnetic field of inductive apparatus and the generator or a condenser. If I find I can't, I think of the oscillating flywheel and the spring—that is something I can easily visualize and that always enables me to recall the electrical condition to mind."

"Fine," responded the engineer. "That's the idea. There are a few things more I want to explain, but we'll let that go until next time."

Diesel Engine Costs

DETAILED COSTS OF ELEVEN CENTRAL STATION PLANTS LOCATED IN MIDDLE WESTERN STATES SHOW TOTAL OPERATING COSTS OF FROM 5.5 TO 13 MILLS PER NET KILOWATT HOUR

EACH YEAR Diesel engines play a more important and more permanent part in our supply of power and interest in reliable operating cost figures continues to increase. In themselves, cost figures from a single isolated plant mean little, yet collectively these data gathered from a large number of plants are extremely valuable.

Care must be exercised in the use and application of these data, however, because it is not possible to take such a tabulation, pick out a station of the proper size and capacity factor and say, "This will be my cost." The data are of use only as insurance statistics are of use, i.e., to determine the chances of getting such costs.

Particulars	1	2	3	4	5	6	7	8	9	10	11
Station	1	2	3	3	3	3	3	3	3	3	3
No. of units	4	2	2	2	1	1	2	1	1	1	2
Normal rating, kw.	1,424	150	1,440	1,120	820	410	440	240	960	480	1,500
Highest peak, kw.	1,700	75	1,440	1,060	1,000	510	208	240	600	560	1,800
Class of service	Continuous	Continuous	Stand By	Continuous	Continuous	Continuous	Continuous	Stand By	Continuous	Stand By	Stand By
Generated, gross kw.hr.	1,751,200	210,470	2,721,770	2,422,980	2,121,600	1,409,410	641,930	6,500	1,548,990	969,410	2,274,700
Net generation, kw.hr. 1932	1,720,413	194,106	2,597,100	2,327,071	2,044,862	1,358,286	618,980	68	1,521,813	929,460	2,223,852
TOTAL COSTS IN $											
Maintenance	$ 1,376.93	$ 2,354.04	$ 2,822.57	$ 2,565.91	$ 2,024.41	$ 1,801.28	$ 431.21	$ 79.42	$ 727.54	$ 431.49	$ 871.05
Supt. and labor	2,614.52	2,148.56	3,390.55	3,968.29	3,424.66	4,188.35	3,040.80	1,114.51	2,360.32	2,462.48	3,158.70
Fuel	5,048.63	1,382.59	10,129.45	9,799.56	7,589.45	4,644.97	2,957.25	31.15	4,276.92	2,952.56	6,925.74
Water	269.61	86.29	240.36	135.03	349.30	272.86	294.46	68.04	159.49	131.62	326.26
Lubricants	773.58	291.53	1,684.22	1,189.10	781.31	371.71	289.09	5.47	436.03	493.36	566.54
Miscellaneous expense	166.56	182.51	1,142.17	860.94	435.06	730.75	324.74	457.38	358.73	591.85	451.32
Total oper. costs, 1932	$11,240.13	$ 6,655.52	$ 18,819.12	$17,520.65	$14,564.18	$12,190.92	$ 7,869.57	$ 1,755.87	$12,297.04	$7,066.15	$12,301.61
UNITS COSTS (CT. PER NET KW.HR.)											
Maintenance	0.0800	1.2126	0.0836	0.1103	0.0990	0.1326	0.0674	90.4773	0.0478	0.0464	0.0392
Supt. and labor	0.1836	1.1069	0.1306	0.1714	0.1659	0.3069	0.4961	1366.2613	0.4189	0.2649	0.1410
Fuel	0.3398	0.7123	0.3904	0.3777	0.3666	0.3367	0.4673	35.3977	0.2810	0.3180	0.3114
Water	0.0137	0.0136	0.0093	0.0058	0.0149	0.0202	0.0460	77.5182	0.0104	0.0142	0.0148
Lubricants	0.0450	0.2047	0.0649	0.0511	0.0378	0.0274	0.1353	6.2159	0.0286	0.0531	0.0265
Miscellaneous expense	0.0097	0.0786	0.0436	0.0284	0.0211	0.0237	0.0530	519.6364	0.0221	0.0636	0.0203
Total unit prod. costs, 1932	0.6530	3.4278	0.7246	0.7447	0.7065	0.8975	1.8671	1995.3068	0.8088	0.7502	0.5832
Total unit prod. costs, 1931	0.7290	2.7800	0.9000	0.8700	0.7900	0.8800	1.7500	2.1000	0.8800	0.9900	0.5600
Total unit prod. costs, 1930	0.8600	3.0800	1.9800	1.2000	0.8700	1.0100	1.6000	11.0500	0.8400	7.7400	Not Oper.
Total unit prod. costs, 1929	0.9100	4.1400	4.1800	0.9900	0.9600	1.0800	1.5300	43.0000	0.9100	Not Oper.	Not Oper.
MISCELLANEOUS DATA											
Gal. fuel oil	148,885	30,111	286,563	234,664	203,814	129,355	82,300	738	123.117	83,244	194,103
Ct. per gal. FOB plant	3.9	3.6	3.5	3.7	3.7	3.6	3.6	3.9	3.4	3.5	3.6
Net kw.hr. per gal. of fuel	11.6	5.1	9.1	9.9	10.1	10.6	7.4	0.1	12.38	11.2	11.5
Lub. oil, gal.	1,519	1,122	3,276	2,319	1,483	701	1,544	10	847	1,005	1,149
Cost, ct. per gal.	50.8	52.7	51.4	52.4	53.0	53.7	57.7	51.0	49.8	51.2	51.2
Net kw.hr. per gal. lub.	1,133	173	793	1,004	1,392	1,938	397	6.0	1,793	925	1,935
LABOR HOURS											
Maintenance	1,430	486	650	1,432	1,339	1,108	187	-	494	231	560
Operating	9,482	8,959	4,886	9,599	8,574	9,536	9,260	4,125	10,358	8,913	6,618
Total	10,912	9,544	5,521	11,031	9,913	10,644	9,447	4,125	10,852	9,144	7,098

An insurance man might pick out a man on the street and knowing his age might say from his data, "Your chances of living 10 yr. are 2 to 1." By examining the man more thoroughly as to the condition of teeth, eyes, ears, internal organs and method of living, he might be able to say, "Your chances of living 10 yr. are 3 to 1."

Similarly with sufficient Diesel cost data, an engineer might pick out a certain size plant and say, "Your chances of making power for $0.015 per kw.hr. are 2 to 1." By examining some of the physical factors of the proposed plant he might be able to say, "Your chances are 3 to 1."

Physical factors are the type and size of engine, the auxiliaries used, the cost and grade of fuel and lubricating oil, service, maintenance and operating attendance. Obviously, unit fuel cost will be lower the heavier the engines are loaded, but maintenance costs will be increased. Lubricating costs depend largely upon the number of operating hours.

In the 11 stations tabulated below the total cost in mills per kilowatt-hour runs approximately equal to $5 + 0.1C$ where C is the capacity factor in per cent, capacity factor being the ratio of the average load to the total rated capacity. These stations are all in central station service in middle western states, some on standby and some on continuous service. The data are particularly complete and in addition to the unit cost of various items include the quantity and price of oils and the actual labor hours. Superintendence and labor runs from $110 to $125 per month per man.

CONNECTION of each penstock in a hydraulic plant to one turbine unit avoids difficulties with distribution of the water to turbine runners.

POWER PLANT ENGINEERING April 1933

Arc-Welded Steel Penstock*

By Clayton M. Allen**

IN OCTOBER, 1932, was placed in operation at the Bureau's San Francisquito plant No. 2, the first all-electric, arc-welded penstock in the United States. Three units are in use of 20,500 hp. each under head of 530 ft. Two of the penstocks are riveted, the third and last being welded, the total flow of the system being for 1000 ft. sec. These penstocks carry from the end of a tunnel, down a side hill on concrete piers to the power house located at the former creek bed, as shown in Fig. 1.

Specifications on Plate

Bids on specifications for riveted and welded construction revealed that welded shop fabrication would cost some 13 per cent more than riveted but it was estimated that saving in installation would offset this, while friction loss would be reduced by elimination of rivets and butt straps. Contract was, therefore, given to Consolidated Steel Corp. of Los Angeles for welded fabrication of 40 straight sections, 9 elbows and 2 expansion joints. Plate was to be grade A, flange quality for forge welding according to A.S.T.M. specifications A89-30, of lengths to require but one longitudinal weld and about 9 ft. wide. Three pipe lengths were shop-welded at the plant into 27-ft. sections for field assembly. From 7 ft. at the top to 6 ft. at the bottom, diameter varies in 3-in. steps and the thickness from 3/8 in. to 7/8 in. in 1/16-in. steps. Nine hundred feet or 64 per cent of the total length is of 3/8-in. plate and 7 ft. diam. Changes in diameter were by short tapered sections and, in direction, by 9 elbows of 3 to 22 deg. angle, four being compound horizontal and vertical angles.

Longitudinal joints were butt welded in the shop by special machines designed by the fabricating company's engineers. Inside round-about joints were also made by a special welder, outside welds being made by hand. The pipe was supported on an inclined structural steel rack and rotated slowly by motor-driven rollers so that welders sat on horizontal platforms with work always in flat position. Three welders worked at once on a 27-ft. section, one to each plate, the strap being welded onto the up-stream end of the section at the shop.

Type of Joints

Figure 2 shows a section of the circumferential joint with pipe ends turned 2-deg. taper on the outside, beveled to 30 deg. on the end, with double-taper-bored butt strap 8 in. wide welded to the pipe ends, which were spaced 1/4 in. apart to give welding space with 1/8-in. straight sides, the balance beveled 60 deg. This gave weld metal 1/8 in. less than plate thickness, with straps the same thickness as plates except that, for field joints on 3/8-in. plate, the straps were 7/16 in.

Procedure in shop fabrication was to tack weld the inside butt joint and one outside lap joint, then finish these joints in the same order, finally welding the closing lap joint, so as to reduce locked up stresses to a minimum. On the 3/8-in. plates, machine welds were made in two passes, one outside, one inside. For plates of greater thickness, the number of passes ran as high as one inside and four outside. For inside, circumferential-joint

*From a paper before Los Angeles Section, American Welding Soc.

**Los Angeles Bureau of Power and Light.

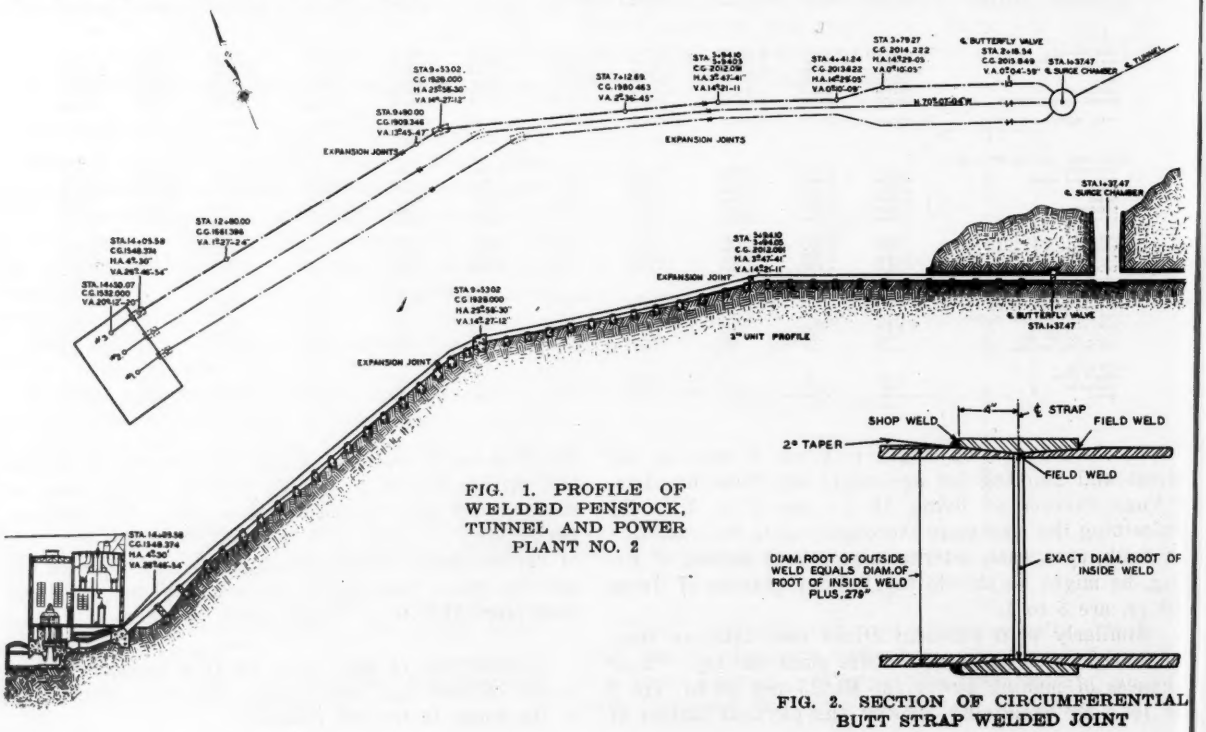


FIG. 1. PROFILE OF WELDED PENSTOCK, TUNNEL AND POWER PLANT NO. 2

SHOP WELD
℄ STRAP
FIELD WELD
2° TAPER
FIELD WELD
DIAM. ROOT OF OUTSIDE WELD EQUALS DIAM. OF ROOT OF INSIDE WELD PLUS .278"
EXACT DIAM. ROOT OF INSIDE WELD

FIG. 2. SECTION OF CIRCUMFERENTIAL BUTT STRAP WELDED JOINT

machine welding, layers were two or three according to plate thickness, except that a few single-pass machine welds had a second pass put on by hand. Outside lap welds, made by hand, had one to four beads.

By varying the number of beads or layers, it was found possible to improve the texture of the weld metal and reduce the tendency to blow holes, also the size of such as did appear. The writer believes that the great advantage of multiple bead work is the possibility of inspection of the inside of the weld while it is being made. Each bead was thoroughly wire brushed before applying the next one, also at the end of each bead when an electrode was changed, so as to exclude slag. Lightweight, fast-hitting air hammers were used to peen-hammer each bead as it was completed, as this was found to increase quality and strength of the weld.

Preparatory Practice

These refinements were introduced as the result of experiment and test on practice welding which was started soon after placing the order for the penstock, as investigation showed that little had been done in welding pipe of such large diameter and thickness by the process to be used. Welders drawn from the preferred civil service list of the city and previously tested on oxy-acetylene and bare rod welding were found to have little experience with coated-rod work, hence it was necessary to develop best methods for field welding and to train the welders in the work, since field welding must be done in any position necessary, yet sound welds were of utmost importance.

Practice welds were tested to destruction and examined for texture, penetration and blow holes. Wedge tests more than any others gave means to examine the inside of welds which often surprised the welders. With practice, quality improved and at the end it was common to tear plate metal in testing rather than disturb weld metal. Tension tests on some 7/8-in. butt welds showed 83,000 lb. per sq. in. of reduced weld section as against 45,000 lb. required minimum plate strength.

Tests Used

For the penstock, all tests were according to A.S.M.E. code for Class 1 unfired pressure vessels, except that 7/16-in. and 3/8-in. plates were not stress relieved. At one end of each longitudinal weld, test specimens of the same material were attached as the longitudinal weld was made. Specifications called for samples to be cut from the weld in each finished section, but welds were found so uniform that this method of testing was used only once.

For testing finished joints to locate leaks, an unique method was used. Holes 1/4 in. diam. were drilled through from the outside of the butt strap of each shop joint, one on each side of the butt weld. Applying high-pressure soap test through these holes gave separate test of each lap joint weld and double test of the butt joint weld, insuring the tightness of each.

All material 1/2 in. and more thick was stress-relieved, the elbows in two heats, one at each end, after internal bracing to minimize deformation. One hour in the furnace at 1100 to 1200 deg. F. was followed by cooling in still air.

Five-minute hydraulic pressure test was given each piece, pounding the welded seams, meanwhile, with an 8-lb. hammer. Ends of elbows were left long and dished heads welded on for the pressure test. After testing, the heads were cut off and elbows checked for dimensions and alinement. Test pressures were from 180 lb. per sq. in. for 3/8-in. plate to 485 lb. for 7/8-in.

Tests being completed, the fit of each section with its adjacent sections was checked, since a misfit on a 10-t. piece of piping high up on a hill side at 42-deg. to the horizontal would be no joke to rectify. When finally passed, sections were transported by the Bureau in the sequence required on the job.

Field Work

As there were two expansion joints and a concrete anchor at the brow of the hill, assembly was handled from three points, starting erection from the bottom end of each section. To eliminate possible difficulties from temperature changes and provide more agreeable working conditions, most of the welding was done at night, when pipe and workers were not exposed to direct rays of the sun. Also on the steep, 42-deg. slope, welding was limited to time when no erection crews above were working, due to hazard from falling rocks.

The ideal program was to erect a section during the day and tack weld the joint at half a dozen points equally spaced around the circumference. Then at sundown start welding, getting in two 8-hr. shifts before erection started next day. The effort was to keep approximately the same number of beads on every part of the periphery but this had to be varied somewhat due to the difficulty of working on a small level platform inside and upon scaffolding outside of a pipe line laid at 42-deg. to horizontal. The inside butt weld was completed first, then the outside lap weld, but sometimes both could not be completed before the next section was installed.

Five sections that went into the penstock tunnel were lined up just outside and, using a bell hole and sun shades, were welded in one location, working continuously, the completed line being jacked into the tunnel as each section was welded on.

Each welder had a helper whose duties were to clean and peen hammer each bead, supply welding rod, water and electric light and fill out daily reports of work completed, rod used, energy consumption and delays for erection. A maximum of eight welders was used, one as a straw boss and with the erection crew for tacking joints.

Previous to erection, sections were sand blasted and painted inside with bitumastic enamel. After erection the outside was given two coats of graphite paint.

Erection Data

Data on erection are as follows, the 33 joints in 7-ft., 3/8-in. pipe being averaged and the 17 joints on other diameters and thicknesses being averaged as the variation in conditions made it difficult to separate the figures:

Type of Weld	Time, Hr.	No. Beads	Electrode, Lb.	Elec. Kw-hr.
7-ft. Diam., 3/8-in. Plate				
Butt	12.8	10.3	20.7	48
Lap	11.0	8.4	18.9	46.2
Other Diam. and Thickness				
Butt	28.2	24.3	44.0	106
Lap	19.1	16.7	30.5	69

Readers' Conference

Diversification Factors in Industry

AN INTERESTING STUDY of the power requirements of different industries can be made from the motor and generator capacities of plants collected and published by the Census of Manufacturers. The accompanying table shows, in the second and third columns, the installed motor capacity driven by power generated in the plants and the installed generating capacity in the same plants. These figures are as originally tabulated and show the motor capacities in horsepower and the generator capacities in kilowatts. In the fourth column is calculated the ratio of motor horsepower to generator kilowatts or the motor horsepower installed for each kilowatt of generating capacity.

DIVERSIFICATION FACTORS IN INDUSTRIES

Industry	Hp. motors installed	Kw. gen. capacity	Hp. / Kw.	0.9 Kw. / 0.73 Hp.
Textile	1,044,623	973,891	1.07	1.13
Leather	119,994	110,021	1.08	1.12
Chemical	533,039	451,509	1.225	0.987
Paper & Allied Ind.	1,248,776	968,021	1.29	0.94
Food	642,530	475,695	1.35	0.896
Non-ferrous Metals	343,512	252,357	1.36	0.89
Printing	31,002	22,615	1.37	0.883
Stone, Clay & Gravel	812,862	579,184	1.40	0.864
Forest Products	900,862	634,028	1.42	0.852
Transportation	481,682	310,072	1.55	0.780
Repair Shops	278,247	179,664	1.55	0.78
Miscellaneous	173,457	111,391	1.56	0.775
Rubber	240,921	150,569	1.59	0.76
Machinery	793,463	480,461	1.65	0.733
Petroleum & Coal	604,471	332,507	1.82	0.664
Iron & Steel	4,106,875	1,761,940	2.33	0.519
Total	12,376,376	7,793,875	Av. 1.59	Av. 0.76

Industries are arranged in the increasing order of this ratio. Studies reveal the wide difference in the diversification factors ranging from the so-called light industries such as textile and leather to the so-called heavy industries such as iron and steel, machinery manufacturers and railroad shops. For instance the textile industry has installed 1.07 hp. in motors for each kilowatt of capacity while the iron and steel industry has installed over twice as much, that is, 2.33 hp. for each kilowatt of generating capacity. The textile industry could pull every motor in the place and have excess generating capacity while the steel industry could pull only about half their connected load with the generating capacity available. There is, or may be, some slight discrepancy in the factors because lighting is not included in the figures.

Light industries have steady loads apparently closely related and with a high demand factor while the heavy industries have intermittent loads with low demand factors. The values in the last column are proportional to the demand factors. The values were calculated by dividing the power requirements of the connected load, in kilowatts, assuming 90 per cent motor efficiency, into the generating capacity. If greater than unity it means that there is some spare generating capacity, if below unity the figure indicates the maximum demand factor that could be handled while running all generating capacity. Perhaps it might be considered a kind of "power imperfection factor" of the industry.

Brooklyn, N. Y. P. F. ROGERS.

Driving Conveyor Belt Idlers By Motors

REFERRING to the interesting letter from England by W. E. Warner, page 98 of the February number of Power Plant Engineering, I would call his attention to the fact that in the United States electric power transmission systems are already in use which are so perfectly synchronized that any number of motors may be used along the conveyor without any mechanical connection whatever and the motors can be depended upon to be in exact step at all times. That is, one motor will not be dragging while the other is pulling. The effect is the same as though the machine parts were actually geared together. The advantage is that there are no gears, no gear noises, no connecting shafting or chains—neater appearance. All of the motors pull simultaneously, provided there is any pulling to be done and provided the motors are not overloaded.

Thus in one instance we have three motors each driving its own section of a given conveying system. The speeds of these motors are so accurately controlled by means of the electrical hook-up that exactly the same results are produced as though the various parts of the system were interconnected by positive mechanical drive.

In another instance—a large paper winder—the paper leaving one section of the machine and entering the other section must have a definite tension. The tension is continually maintained by an electrical hook-up with synchronized motors in each section.

As mentioned before in Power Plant Engineering, however, I wish to re-state that "an idler pulley cannot drive and still be an idler pulley." I suggest a more suitable name for such a pulley as—"Auxiliary Drive Pulley." Just why writers persist in applying the term "idler" to wrapper pulleys, and to "helper pulleys," as above, is beyond my comprehension. An idler is a pulley that simply idles and that does nothing else.

Newark, N. J. W. F. SCHAPHORST.

Use of Reflected Light

IN AN ARTICLE in a recent issue of POWER PLANT ENGINEERING a scheme was shown whereby a piece of white paper was used to reflect light at such an angle that it made possible the reading of a meter located in a dark place without the use of a flash light. This brought to mind various ways in which we use the same idea around our plant that might be of interest to other readers.

On our engines we have sight feed oilers connected by pipe systems to a main oil reservoir and some of them are so located in relation to the source of light that it is impossible to see the oil as it drips past the sight glass. By placing a finger behind the glass, as shown in Fig. 1, the oil can readily be seen dropping through the sight glass.

The supply tanks to this system are kept filled by a pump connected to the exhaust valve mechanism of the engine as shown in Fig. 2. This was made out of an old hand oil pump and operates quite successfully,

taking the oil from the reservoir of a home made filter into which all waste oil from the engine is returned by a system of pans and drain pipes. The only trouble is that the drain or overflow from the supply tanks was not put in large enough and the tanks must be watched closely to prevent overflow. The supply tanks

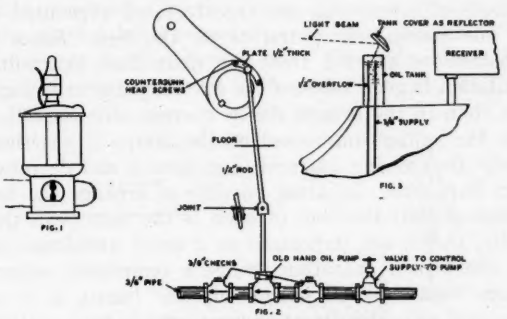


FIG. 1. MAKING OIL FEED VISIBLE
FIG. 2. OIL SUPPLY TO TANKS
FIG. 3. REFLECTED LIGHT TO SHOW OIL LEVEL

have removable covers but even with the cover removed it is difficult to see the oil level in the tank, so the cover is used as a reflector as shown in Fig. 3.

Various other problems of a similar nature arise quite often which can usually be solved by the use of a reflected light.

Superior, Wis. FRED S. RUTLEDGE.

Interest and Depreciation Charges

REFERRING to the article by James O. G. Gibbons in the February issue, I would like to give a different method of figuring interest and depreciation charges which is used by some of the public utilities. This method while different from the one given in the previous article arrives at practically the same result.

The same illustration is used—the case of a machine which is depreciated from $1000 to zero in 10 yr., with an interest charge of 6 per cent per annum. According to the method given in Mr. Gibbons' article, the depreciation charge is assumed to be $100 a year, and it is further assumed that this charge is made at the expiration of each year. An equation follows giving the average interest rate on the original investment in order to take care of lower interest charges on a depreciated investment each year. This formula is

$$\text{Average interest} = \frac{M+1}{M} \quad \frac{(\text{Investment} \times 0.06)}{2}$$

which in this case equals 33 dollars, making a total annual charge of $133.

The method I have always used assumes that 6 per cent interest on the original investment must be earned each year; in other words, a charge of $60 interest is made annually. Depreciation is figured on a sinking fund basis, assuming that the depreciation charge is paid as cash into a sinking fund drawing 6 per cent interest compounded annually, the same rate as the interest charge. The formula used is

$$Y = S \times V$$

Here "Y" is the annual payment or annuity which if set aside each year will amount with accumulated interest to a given sum "S" at the end of "N" years. The factor "V" may be obtained from any annuity table.

Using the above example of $1000 depreciated to zero in 10 years, the annuity to draw 6 per cent interest compounded annually, the factor "V" from the tables for a term of 10 years is found to be 0.07587. Substituting this factor in the equation above and $1000 for "S" gives an annual annuity or depreciation charge of $75.87. This added to the $60 annual interest charge amounts to $135.87 as compared with $133 as figured by the method given by Mr. Gibbons.

The two answers check extremely closely and as Mr. Gibbons states are far more accurate than those obtained by the usual method of figuring straight 10 per cent depreciation and 6 per cent interest, a total of 16 per cent annually. The annuity method seems to me to be the more logical of the two, probably because it is the one I have always used. The important point is the fact that the sum of the interest and depreciation charges in this case should be approximately 13½ per cent and not 16 per cent as given by the method most commonly used.

New York, N. Y. ALFRED W. FOX.

Plugging a Broken Pipe Line

IN THE March number of Power Plant Engineering G. A. Luers offered a solution to this problem but this method, the bevel taper plug of wood, has several disadvantages associated with it. In the first place, it is doubted that the effectiveness of the plug will be great enough to warrant the expense of having one or more plugs made for each size water pipe where a possible occasion would demand immediate use.

In the second place, the large size emergency valve would mean a sloppy looking repair, unless the added expense of replacing the emergency valve, when the line was shut off, was not considered. The use of a pipe cutter, as suggested by Mr. Luers, would certainly make the insertion or removal of the plug difficult, on account of the burr on the inside of the pipe; further, if the plug were inserted, the inserting or removing of the plug would so mutilate it that future use would be doubtful.

Corrosion and scale in a water pipe that has been in service for any length of time would render a bevel plug difficult to insert and it is doubtful if it could be made as tight as a straight round taper plug.

Theoretically, the idea is a good one, but practically, it would be extremely difficult to carry out. If the engineer gets a satisfactory break, everything will be all right, so far as a plug is concerned, but after many years in charge of piping, I have yet to see a broken pipe line that would demand the use of a bevel taper plug in preference to the regular straight taper plug.

Several years ago, I decided to try these bevel tapered plugs and found the above disadvantages; after abandoning these plugs in favor of the ordinary taper plug, I found I got much better results.

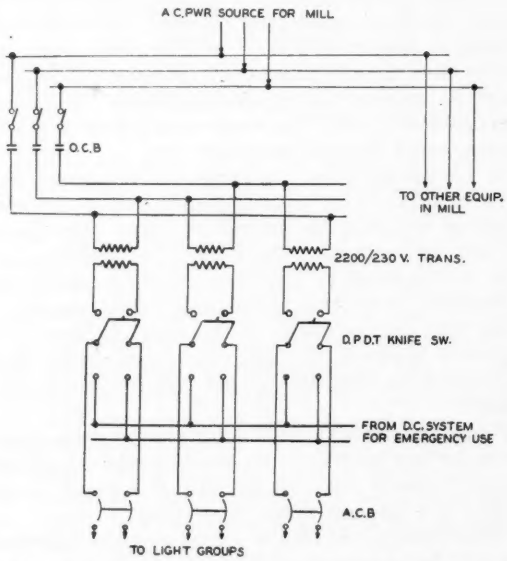
Brooklyn, N. Y. WILLIAM ANDERSON.

MAXIMUM unconsumed coal when running at full load should be not over 4 per cent for grate or stoker firing, not over 2 per cent for pulverized fuel.

Overcoming Lighting Troubles in Steel Mills

GOOD LIGHTING and a minimum number of lamp renewals—in short, economical illumination—is the desire of any plant. To get this economy, an unvarying voltage of the rating of the lamps must be kept impressed upon them. They thus give their maximum light with maximum life. In steel mills, because of the fluctuating voltages encountered, a power source of steady voltage is rare but a method to approximate it more closely than before has been developed and is shown in the accompanying sketch.

Up to the past few years, it was the invariable custom in one middle-western steel mill to connect any new installation of lights to the nearest direct current feeder whether or not the latter was already feeding other electrical equipment such as mill motors. These motors being frequently accelerated, plugged and reversed drew large currents and thus caused extreme fluctuations of voltage at the lights. As a result, they flickered annoyingly and many were burned out by the high voltage peaks. In several cases, as the years passed, new electrical equipment was connected to the direct current feeders but the amount of copper in the lines was not increased. Consequently, high voltage drops in the lines resulted, causing low voltage at and near the feeder ends. Complaints became numerous that the



CONNECTIONS FOR MILL LIGHTING SYSTEM

motors connected at these places ran too slow and thus lowered the production rate. To satisfy the complainants, the voltage at the substations from which these radial feeders were fed was increased to compensate as much as possible for the line drops as it was much cheaper to do this than to install additional copper in the lines. This meant that the voltage impressed upon the feeders near the substations was comparatively high. As the lamps connected to these lines at these points received the full benefit of the high voltage, burn-outs and the necessary replacements soon increased the light expense to an abnormal amount.

Because of these experiences with direct current lighting, a new power source was developed to feed the lights in the new rolling mills erected as the result of an expansion program started several years ago. This source was secured by the installation in each new mill of transformers of correct voltage and fed by the incoming alternating current power source. Several methods of connecting the transformers were used but the one shown was found to be the best. Since the transformers are fed from the main line, the voltage regulation is good because the diversity factor is higher here than in the branch direct current circuits. Therefore, the voltage impressed on the lamps is practically steady, thus giving uniform illumination and decreasing lamp burn-outs. It is not possible to arrange the lamp groups so that the load of each is the same but, practically, this is not important as a small unbalance does not affect good operation. Since a completely separate system was installed exclusively for lamps, it is not grounded as is the direct current system from mill motors in exposed locations. Not all the lamps in any one rolling mill are fed from the new alternating current source. To prevent the ordinary mill worker from coming in contact with the primary voltage of the transformer in case of trouble on its windings, only the large overhead and side lights, the major portion of the lamp load, are fed from the transformers. For this reason, also, the small floor and extension lights receive power from the direct current system.

From the results of several years' experience, the supplying of a.c. power to the lamps instead of d.c. power has given complete satisfaction. Uniform lighting has resulted and the number of necessary replacements has fallen to a small number.

Hammond, Ind. S. EIN.

Compression in Engines

REFERRING TO P. F. Rogers' comments on "Compression in Engines," on page 781 in the November issue. Regarding cross-compound engines, the statement is made, "The receivers and low-pressure cylinders are not built to stand pressures which may be built up in emergencies." I do not think that is quite correct. Some years ago I had occasion to increase the receiver pressure in a compound engine because of unusual load conditions, but before doing so, I consulted the builders, who informed me that both receiver and low-pressure cylinder would stand full boiler pressure safely.

Brooklyn, N. Y. CHARLES J. MASON.

Diesels Make Notable Advance

IN THE TABULATION on page 41 of the January, 1933, issue, headings on cols. 12 and 13 for the last eight stations, all of The Great Lakes Pipe Line Co., should be changed. Fuel figures of 18,000 refer to the B.t.u. per pound and the figures of 19.1 and 15.4 respectively refer to horsepower hours per gallon. These engines are direct connected to reciprocating pumps and their output is normally expressed in horsepower hours rather than kilowatt hours as indicated at the top of the column.

Synchronizing With the Power Co.

COMMENTING on C. P.'s problem of "Synchronizing with Power Company," in the December issue, a synchronizing device will not be necessary and the operation can be made entirely automatic but an exhaust steam pressure regulator will be required.

A number of different types of such regulators are on the market but the one that will best answer to his conditions is the diaphragm type. One side of the diaphragm is to be connected to the exhaust header and the

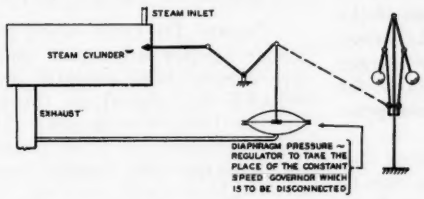

STEAM INLET
STEAM CYLINDER
EXHAUST
DIAPHRAGM PRESSURE REGULATOR TO TAKE THE PLACE OF THE CONSTANT SPEED GOVERNOR WHICH IS TO BE DISCONNECTED

DIAGRAM SHOWING ACTION OF EXHAUST STEAM PRESSURE REGULATOR

other side open to the atmosphere, while the stem is to actuate the steam admission to the engine. The present constant speed governor will have to be dispensed with, with the exception of its over-speed feature, and the diaphragm regulator fill in the omission. The accompanying sketch is given as additional explanation.

Chicago, Ill. N. T. PEF.

TO OPERATE a constant speed engine driven alternator in parallel with the power company's circuits, as proposed by C. P. in the December issue, will probably prove quite difficult. That is without some means of adjusting the speed of the engine while it is running.

As far as synchronizing is concerned, it can be accomplished by using the throttle valve to control the engine's speed. While not so convenient as a motor driven means of changing the engine's speed, the same results can be obtained.

Controlling the load the alternator will carry is an entirely different matter, however. Some power plants do use constant speed engines, without means of adjusting their speed while running as alternator prime movers. Where such practice is followed the greatest part of the load is carried on these units, and a sufficient capacity in variable speed units provided to care for the load fluctuations. The governors on the constant speed units are of course all set exactly alike, consequently they divide the part of the load allotted them by the operator's controlling the variable speed machines. Also in such cases at least all the constant speed engines are supplied steam at the same pressure.

So assuming the power company's frequency and Ball engines' steam supply pressure to be constant, the governor can be set so the alternator will carry the desired load, but to carry a different load it will be necessary to reset the governor. And as such settings would necessarily be of the cut and try variety, they are not to be recommended for frequent changes. Another possibility for load control is the use of the throttle valves, but this will cause the governor action to become less sensitive and even small pressure variations in the steam supply would affect the load greatly. So even if within the range of possibility it is my opinion that this method of operation will prove extremely unsatisfactory.

In operating in parallel with the power company, even with governor control, I believe it will be good practice to keep the engine throttle valve closed enough to cause the engine to slow down if much over 500 kw. is put on the alternator. That is unless suitable emergency protection in the form of circuit breakers is provided. Some trouble may be experienced too with cross currents between the two systems since the wave-form and characteristics of A.C. generators are not all alike. When the generator is paralleled with the power company and carrying the desired kw. load, try moving the field rheostat each way from where it is set. The point where the lowest ammeter readings are obtained without reducing the kw. reading is the best setting to operate at.

Chicago, Ill. ROY M. STINSON.

WITH REFERENCE TO the question by C. P. on page 831 of the December, 1932, issue, regarding the matter of synchronizing with the power company, I assume that C. P. has in mind not the actual process of synchronizing by means of lamps or synchroscope, but rather the proper proportioning of the load on the generator after it has been synchronized with the power company's system. The load which a machine operating in this fashion will carry depends upon its throttle opening or governor setting. The speed is fixed by the speed or frequency of the system to which it is connected so that the load on the unit can be varied at will to suit any requirement of the heating system, regardless of the local load; in fact it is possible to do this automatically to maintain certain pressures on the heating system.

However, should the demand of the heating system be such that the kilowatt load would exceed that of C. P.'s local load, energy would be returned to the supply company's system and the meter would reverse its rotation if only one meter for incoming energy was used. Should there be a possibility of such a condition occurring it would be best to make arrangements with the supply company either to install two sets of meters, one for incoming and one for outgoing energy, or to have it definitely understood what the operating conditions might be. This situation exists, to the writer's knowledge, in the case of a large university in the middle west where during the early morning hours when the kilowatt load is very light, a great deal of steam is needed for heating the class-rooms previous to recitations. It would be impossible to heat the rooms except by by-passing live steam if arrangements had not been made to parallel with the supply company's system and pump energy into it during the period referred to. As the university kilowatt load increases at the beginning of the university activities the kilowatt load being sent into the supply company's system automatically decreases.

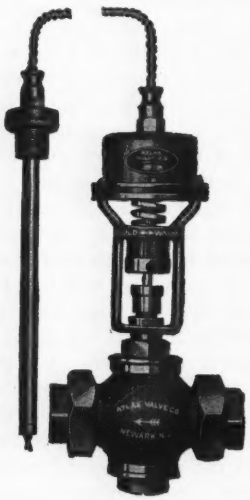
Brooklyn, N. Y. C. O. VON DANNENBERG.

RESISTORS USED in various types of heating units are generally alloys of nickel and chromium and in some cases nickel-chromium iron. Other alloys used for lower temperatures are copper-nickel-zinc and copper manganese-nickel. An alloy of 80 per cent nickel and 20 per cent chromium is especially durable and good for temperatures of 2000 deg. F.

New Equipment

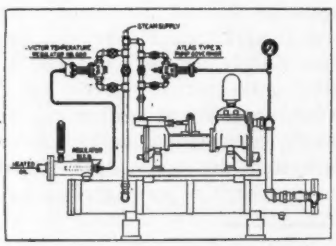
Temperature Regulators

IN THE VICTOR temperature regulators made by Atlas Valve Co., 282 South St., Newark, N. J., a regulator bulb, inserted at the point where temperature is to be regulated serves as a boiler to vaporize the contained thermostatic liquid. Vapor pressure is transmitted through capillary tubing to a bellows unit made of seamless bronze tubing, which changes length as pressure



changes. This bellows is mounted in a casing at the top of the regulator valve so that the bellows movement controls the position of the valve stem.

Four types of regulator valves are made for different services: the balanced type double seat with spring adjustment; the needle type,



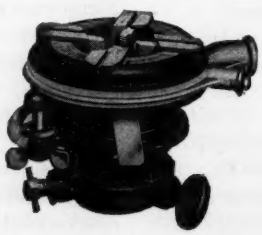
single seat with spring adjustment; the balanced type, double seat with lever and weight adjustment; the single seat, self contained, pilot operated with spring adjustment. The first is adapted for liquid tanks or heaters, where steam pressure is 25 lb. or less; the second is for use where but small amounts of steam are needed and tight seating is essential but is available only for steam pipe ½ in. or smaller because of the power required to actuate the valve; the third is suitable for larger valves; the fourth is especially for close regulation and for steam pressures above 25 lb.

Where the service requires special regulators, other types can be furnished on request. Some of the applications are to oil heaters, to desuperheaters, to hot water tanks.

New Pipe Tools

BEAVER POWER ADAPTER including a base and range of die heads from ¼ in. to 6 in. is arranged to be operated by any standard electric or air drill by means of a driving spud. It will work right or left handed and can be mounted on a bench or on legs of 1-in. pipe.

In the 12-R Beaver ratchet-drive die stock is found a self-contained tool with one set of dies, no bushings, fully adjustable for over, under or standard size threads. It is for 1 to 2-in. pipe for steel, iron, cast iron, brass or copper pipe.

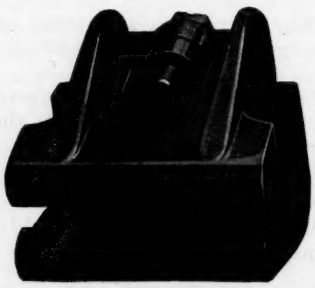


For copper tubing, sizes ⅛ to ¾ in., a wheel cutter has been developed to produce clean square ends without crushing the tubing.

All these are made by The Borden Co., Warren, Ohio.

Ideal Fuse Clamps

CLAMPS for knife blade fuses to insure proper alinement and positive contact have recently been developed and placed on the market by the Ideal Commutator Dresser Co., Sycamore, Ill. They are applied by slipping the clamp over the



switch fuse blocks after the fuse is in place and turning down on the machine screw. This clamps the contacts together in a vice-like grip and prevents undue heating.

Portable Draft Gage

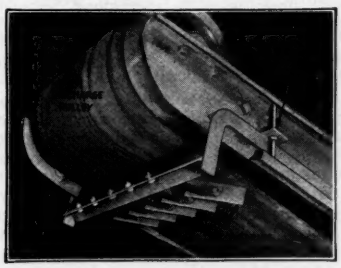
IN THE NEW dry type line of draft gages of The Hays Corp., Michigan City, Ind., a slack leather diaphragm unit is used with no liquids. It is provided with reel for rubber tubing, clips for metal smoke pipe tube, zero point adjusting screw, aluminum case in black lacquer fin-

ish, slip-over metal cover, graduations in 1/100 in. for standard ranges of ½ in. or 1 in. as shown. Other ranges can be furnished for differential or forced draft, with ranges 0 to 5 in. and +0.2 to —0.3 in. for portable use or for permanent mounting in wall or flush type.

Conveyor Belt Cleaner

IN USING the belt conveyor, ideal in many respects for moving material, one difficulty has been to clean the belt after its load has been discharged. Unless perfectly cleaned, trouble from building up of material on bend pulleys and formation of dribble piles under the conveyor are likely to follow. Negligible as these may appear, they may turn the balance in favor of other types of conveyors not so well suited for a given service.

After 2 yr. of study and experiment with other types of cleaners, old and new, Stephens-Adamson Mfg. Co., Aurora, Ill., has developed its Spring Wiper, to be placed just back of the discharge point on the return run of the belt. It consists of a row of thin steel plates, set perpendicular



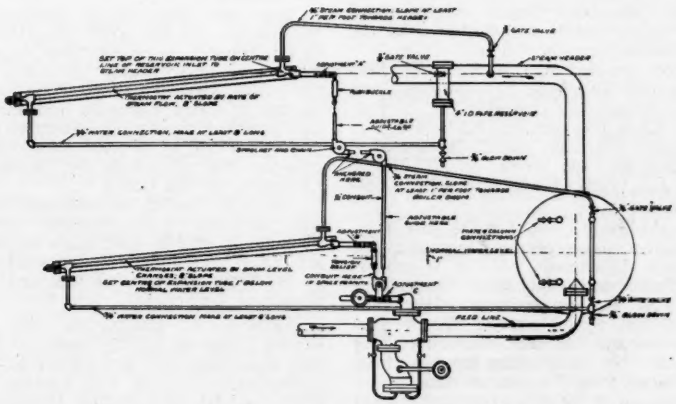
to the belt surface, diagonal to belt travel, with each plate pressed firmly against the belt by an individual spring which acts through a pivot at the middle of the plate, so that the plate will seat perfectly against the belt. Adhering material is thus plowed off into the discharge chute or into an extension.

Many tests and daily use over 5 mo. on 18 large conveyors handling coal, refuse and sand are stated to have demonstrated that cleaning is 100 per cent effective over a range of material from dripping wet to dusty dry, no dirt or water being dropped from the entire return run of the conveyor. Simplicity, low cost, compactness and ease of application seem obvious. Belt wear is said to be reduced because of clean belt running over bend pulleys and return idlers.

IDLERS of 6 in. diam. with Timken-Roller Bearings are an addition to the line of the Fairfield Eng'g. Co. belt conveyor equipment. Troughing idlers consist of three demountable and interchangeable pulleys, the two outer held at an angle, supported by malleable iron brackets. Return rollers are single, on steel brackets carrying the belt flat. These idlers are built for belt widths from 14 to 60 in.

New Design Feedwater Regulator

THIS IMPROVED design of the Copes series type regulator feeds in accordance with steam flow, with compensation for water level. The steam-flow thermostat can be located near the connections to the steam header and influence of either steam-flow or water-level thermostats can be regulated. Equipment may be a direct-acting or a hydraulically-operated control valve, or a combined feed-flow and water-pressure regulating valve. The Copes regulator is made by Northern Equipment Co., Erie, Pa.



Pointers

INDICATIONS SHOW that industries are modernizing in their power plants. Recent report from Riley Stoker Co. gives the following installations completed: Forstmann Woolen Co. at its Passaic, N. J. Plant, three 60,000-lb. an hr. steam generating units, boilers, superheaters, air preheaters, water-cooled furnaces, insulated, steel-clad settings, pulverizers, burners and flue gas scrubbers; at Garfield, two 80,000 lb. per hr. units with like equipment. Columbia University in New York has 1200-hp. and a 600-hp. boilers with air preheaters, water-cooled furnaces and Harrington stokers. General Aniline Co., Grasseli, N. J. has a 65,000 lb. per hr. unit with boiler superheater, air preheater and water-cooled walls, fired with oil. Finch-Pruyn Co., Glen Falls, N. Y. has two 500-hp. steam generating units with boilers, air preheaters, and water-cooled furnaces fired by Harrington stokers. All which shows that engineers of industrial plants are awake to the advantage of modernizing their plants to increase economy and are acting to secure that advantage.

Prevention of Pipe Corrossion

LABORATORIES of D. W. Haering & Co., Chicago, Ill., have developed a chemical formula, trade-marked "H-O-H," for controlling corrosion and eliminating scale and rust from hot water lines and heaters which is unique in its action and composition. This makes no coating on the piping but controls corrosion by attacking the fundamental causes, combining directly with oxygen to form a stable compound and thus remove oxygen as a factor in corrosion. Carbon dioxide is adsorbed on the surface of the colloid, while scale-forming particles are maintained as suspensoids. The material is easily adjusted for pH control. The base formula frequently requires no adjustments, has a pH of about 5.5, less than 2 per cent mineral matter, reduces Fehling's solution, combines with lime, is partially volatile and is equally well suited for boiler and hot water treatment.

PROPER AND REGULAR lubrication of packings in service is essential to successful operation. Insufficient lubrication, or the use of the wrong kind of lubricant results in excessive friction, scored rods, leaks and the ultimate destruction of the packing. To provide packing users with correct lubricants for packings, The Garlock Packing Co., Palmyra, New York, has developed its Lubricating Paste Compound No. 2 for steam and water packings and Lubricating Paste Compound No. 3 for packings working against gasoline and oils. These are intended to replace the hand-mixed lubricating compounds frequently used for this purpose. When applied to packings at regular intervals they should reduce friction and prolong the life of packings.

News From the Field

PLIBRICO JOINTLESS FIREBRICK Co., Chicago, Ill., announces the appointment of the Geo. L. Simonds Co., Winter Haven, Fla., as its distributor, who will maintain warehouse stocks at Jacksonville and Tampa, for complete installation and boiler setting service.

GEORGE W. FULLER, consulting hydraulic and sanitary engineer of Fuller & McClintock, New York, has been elected Chairman of the Engineering Foundation to succeed H. Hobart Porter. Mr. Fuller was graduated from Massachusetts Institute of Technology in 1890, subsequently studied at the University of Berlin and since 1899 has been expert adviser for filtration plants in New York, Baltimore, Washington, New Orleans, Columbus, Grand Rapids, and other cities. Other officers chosen by the Foundation were as follows:

First vice-chairman, Harry P. Charlesworth, Bell Telephone Laboratories, New York; second vice-chairman, H. C. Bellinger, Chile Exploration Co., New York; D. Robert Yarnall, Yarnall-Waring Co., Philadelphia, and John V. N. Dorr, Dorr Co., New York, Executive Committee.

F. C. EIBELL, who for the past 4 yr. has been manager of the advertising and publicity department of the Worthington Pump and Machinery Corp., New York, N. Y., has resigned. His work during that period marked Worthington as an outstanding industrial advertising account. No announcement has been made concerning his future plans.

WILLIAM R. WALLACE, for 32 yr. chief of the Hinckley Rendering Plant of Swift & Co., at Somerville, Mass., died on Jan. 6, 1933 in his sixty-first year. He leaves a son, Joseph D. Wallace, also engaged in engineering. His many friends in the engineering brotherhood are deeply regretful of the untimely taking away of a good friend and able counselor.

INTERNATIONAL NICKEL Co., Inc., announces that O. B. J. Fraser, forferly in charge of its Research Laboratory, at Bayonne, N. J., is now located in the Development and Research Department at its main offices in New York, in charge of developments in the uses of nickel and nickel alloys, and the industrial uses of non-metallic compounds of nickel.

Norman B. Pilling, formerly in charge of metallurgical research, has been placed in charge of the Research Laboratory. E. M. Wise, whose work heretofore has been largely associated with precious metals, has been appointed assistant.

YEWDALL CONOVER is now chief engineer at Hotel Traymore, Atlantic City, N. J., occupying the position held successively by George and John Armitage. H. A. Conover, his brother, is chief at the Ritz-Carlton.

AT THE NEW Claridge Hotel in Atlantic City, Richard Burroughs has succeeded Charles Chandler as chief engineer.

BREAKERS HOTEL in Atlantic City, N. J., has a new chief engineer, James F. Marshall, one of the oldest members of the engineering fraternity in the city, succeeding to John Clancey.

R. M. STANLEY, electrical engineer, Byllesby Engineering and Management Corp., died Tuesday evening, March 7, at his home in Western Springs, Ill. He had been associated with the Byllesby organization since 1910, having formerly served in an engineering capacity with Sargent and Lundy and the Corn Products Co.

GENERAL AIR CONDITIONING Co., Inc., has been formed to design and install air conditioning, cooling and drying systems, with offices at 155 E. 44th St., New York City. Officers are M. Hitchen, president, A. H. Clogston, vice-president, David H. Knowles, secretary.

DR. EDWARD WESTON of Montclair, N. J., has been awarded the 1932 Lamme Medal of the A. I. E. E. for achievements in the development of electrical apparatus, especially precision measuring instruments.

Born and educated in England, Dr. Weston has to his credit, since coming to this country in his 20th year, improvements in electroplating processes and equipment, dynamo construction, manufacture of lamp filaments and carbons, and practical measuring instruments, the last now made by Weston Electrical Instrument Co. of which Dr. Weston is Chairman of the Board.

He is a member of numerous scientific societies, was president of the A. I. E. E. 1888-89 and holds an honorary LL.D. from McGill University and D. Sc. from Stevens Institute and from Princeton University.

ARTHUR E. BLACKWOOD has been elected Chairman of the Board of Sullivan Machinery Co. and Henry S. Beal, formerly with Jones and Lamson Machine Co. has been elected President to succeed Mr. Blackwood.

HYDRO-ASH CORP., 115 S. Dearborn St., Chicago, announces the election of officers, as follows: James Stokoe, president; Ernest E. Lee, vice-president; Geo. W. Hansen, secretary; John L. Higgins, treasurer.

ASHTON VALVE Co., Cambridge, Mass., has appointed Maintenance Engineering Corp., 1400 Conti Street, Houston, Texas, its sales agents in southeastern Texas.

THOMAS A. MARSH has become a partner in the Ernest E. Lee Co., Chicago, manufacturers' representatives. For 10 yr. Mr. Marsh was chief engineer of the Green Engineering Co., for 7 yr., western engineer for the Combustion Engineering Corp., and for 3 yr. president of the Modern Coal Burner Co.

F. C. Kerns, superintendent of lubricating sales, the Texas Co., has been elected director of the Fuel and Ash group of the Exhibitors Committee, Industrial and Power Shows, Inc., succeeding E. J. Billings of Babcock & Wilcox Co. Mr. Kerns is also chairman of the Oil Show committee of E. C. I. P. S. H. N. Shackleford of Johns-Manville Corp., secretary of E. C. I. P. S., has been appointed chairman of the Membership committee.

ENGINEERS attending the 6th Midwest Engineering and Power Exposition at Chicago during the week of June 25th to 30th will find a new word for their vocabularies which comes from Philadelphia. "Renovizing" power will be the theme of the exposition, or in plain English repair, remodel, and restore power plants, utilizing today's improved equipment and supplies. This will be one of the features of a week which will see the gathering of twenty engineering organizations for their conventions at Chicago, the combined membership of these groups being over 100,000. Leaders in the power field will discuss specific problems of their industry in relation to present day conditions with the idea of outlining practical plans for "renovizing" as a good business proposition.

ASSOCIATE ENGINEERS INC., 1233 E. 144th St., E. Cleveland, O., has been organized and incorporated to do a consulting and contracting business. The officials are J. H. Gleason, president, Geo. P. Webster, secretary, W. Finter, treasurer.

ELY C. HUTCHINSON became President of the Edge Moor Iron Co., Edge Moor, Delaware, on Feb. 1st, succeeding William F. Sellers, retired. Mr. Hutchinson is well known to the steam engineering field and brings to his new connection a wide experience in sales engineering, manufacturing and editorial work. The standing and reputation of the Edge Moor engineering staff as designers fully warrant the selection of Mr. Hutchinson to direct future operations.

B. F. GOODRICH RUBBER Co., Akron, Ohio, has appointed Lucien Q. Moffitt, Inc., exclusive distributor for Goodrich Cutless Rubber bearings in the United States and Canada. Mr. Moffitt has been manager of the rubber bearing department since this development was first placed on the market. Offices of the new distributors are in the Peoples Bank building, Akron, Ohio.

NORTHERN EQUIPMENT Co., Erie, Pa., announces the appointment of J. W. Murphy Co. as Chicago district representative with office at 431 S. Dearborn St.

D. H. SKEEN & Co., 1 N. La. Salle St., Chicago, has been appointed exclusive distributor for Eagle 66 insulating cement which is manufactured by The Eagle-Picher Lead Co.

T. K. MIAL, regional vice-president of the Johns-Manville Sales Corp., has recently been appointed an executive vice-president of that concern, and will be general sales manager of the Power Products Department directing the sales of the company's products in industrial fields. J. A. O'Brien has been appointed assistant general sales manager for the same department.

LUDLOW VALVE MANUFACTURING Co., Troy, New York, has recently appointed the J. W. Frazier Co., 626 Western Reserve Building, Cleveland, Ohio, as its representative in Northern Ohio.

MIDWEST Bituminous Coal Conference, sponsored by Purdue University, University of Illinois and coal trade organizations and held annually since 1928, will be omitted in 1933 and the sixth conference held in 1934. This action is taken because of economic conditions and the desire to concentrate interest in engineering matters to Engineering Week to be held in Chicago June 25-30 in connection with the Century of Progress Exposition.

CHAIN BELT Co., Milwaukee, Wisc., has appointed A. S. Kennedy as manager of its new branch office in Kansas City. Mr. Kennedy is a graduate of the University of Kansas in the School of Mechanical Engineering and, for the past 5 yr. has been sales engineer covering the states of Missouri, Kansas and Nebraska.

For the Engineer's Library

TECHNICAL DATA ON FUEL, by H. M. Spiers, 5 by 7 in., 300 pp. Numerous tables and charts. Third edition. Published by British National Committee, World Power Conference. For sale by American Committee, World Power Conference, 1419 Chrysler Bldg., New York City. Price, $2.75.

This volume, prepared with coöperation of leading fuel authorities of England was first published in 1928, was revised in 1930 and now appears in a revised and enlarged third edition. Thin paper is used, so that it is held to pocket size, in spite of the 75 per cent increase in data over the first edition. As examples of new material added may be cited: Pressure drop in coils, flow of fluids through filter beds, creep data for alloy steels, properties of coal tar, uses of pulverized fuel, determination of CO in flue gases, properties of dry ice (solid carbon dioxide), properties of ethyl fluid compounds. Besides the usual mathematical tables, the book covers properties of fuels and standards, of air, water and gases, temperature measurements, furnace construction and materials, fuel preparation, properties of vapors, combustion conditions, heat transfers. Much data, information and discussion, not readily available elsewhere, has been collected, quite a considerable from recent technical journal issues. Through most of the book alternate pages are blank to provide space for adding such data as the user may find desirable. Mathematical facility is necessary for easy use of the book but tables and charts are well arranged for quick reference without regard to the formulas.

PH AND ITS PRACTICAL APPLICATIONS. By Frank L. LaMotte, Wm. R. Kenny and Allen E. Reed. Published by Williams & Wilkins, Baltimore, Md. Cloth, 6 by 9 in., 255 pages. Price, $3.50.

Although the scientific investigation of the hydrogen ion began over 45 yr. ago, it was only during the past decade that it has assumed practical importance. Today the term pH is a part of the routine vocabulary of every practical man, even though many of these do not have a clear conception of the term or the underlying principles involved in its measurement.

This book is not a scientific discussion of the subject but is intended for the man having charge of the determination and control of the hydrogen ion concentration in industry. The discussion treats of the early history and an explanation of hydrogen and hydroxyl ion is followed by a discussion of buffer action and methods of determining the pH value with particular reference to the colorimetric standards and their use. Possible errors including the effect of salt concentrations completes the first part of the book.

The second part is a detailed discussion taken from actual practice of hydrogen ion determination in industry. Fourteen different industrial applications are covered in separate chapters, the most important to our field being the chapters on water corrosion problems, sugar industry, textile industry, pulp and paper industry, printing processes and general industrial chemistry. Each chapter has a chart showing the zone which past practice has shown to be the most desirable for each step in a given process.

ENGINEERING: A Career—A Culture, is the title of a pamphlet addressed to young men and to parents and teachers prepared by the educational research committee of The Engineering Foundation. It is descriptive of the profession of engineering, of its spheres of action, of the training and the qualities required for its successful pursuit of the obligations it imposes and the rewards it affords. The object of the pamphlet is to make clear the significance of engineering in order to aid a young man in deciding whether he is suited to pursue this profession. Copies may be secured from The Engineering Foundation, 29 West 39th St., New York City, at 15 cents a copy.

POWER ECONOMY in the Factory, by J. C. Todman, 5 by 7½ in., 216 pages, illustrated. Isaac Pitman & Sons, London, England, and New York City, 1932. Price, $2.25.

Prepared to acquaint cost and works accountants and students in these branches with the elements of factory power plants and the utilization of power and steam, this book will undoubtedly aid the accountant or the non-technical executive to a clearer conception of the problems and difficulties of the power engineer. To the engineer, however, it would seem extremely elementary and of value only to the power plant apprentice in getting a conception of the functions of the equipment used in the plant. A distinctive and helpful feature is the summary at the close of each chapter giving the pertinent facts which have been discussed. While written around English conditions and equipment, the fundamental principles are the same as in the United States and the American reader need only to apply them to the equipment at hand.

EXPERIMENTAL INVESTIGATION OF THE FRICTION OF SCREW THREADS made at the University of Illinois, Urbana, Ill., is published in Bulletin No. 247 of the Engineering Experiment Station. This is a 60 page booklet and sells for $0.35.

FALCON Continuous Electric Furnaces for hardening, tempering and annealing strip metal and wire products are illustrated and described in Bulletin 280 issued by H. O. Swoboda, Inc., 3530 Forbes St., Pittsburgh, Pa.

LATEST edition of Foxboro Co.'s Recording Thermometer Bulletin No. 169-1 contains, among new features and additions, descriptions of the Anti-Ambi thermometer, the new Self-Contained portable temperature recorder and the Rotax controller; also a new section describes and illustrates thermometer bulbs and gives a table of recorder charts with typical chart sections. The Foxboro Co., Foxboro, Mass.

FLYNN & EMERICH Co., Baltimore, Md., announces in a leaflet a new underfeed stoker with electro-hydraulic drive and ram feed to serve boilers with rated capacity from 25 to 250 hp. for small power plants in buildings and industries.

MOTOR REDUCTION UNITS made by Allis-Chalmers Mfg. Co., Milwaukee, Wisc. are described in its illustrated Bulletin 1164.

ATLAS VALVE CO., 282 South St., Newark, N. J., is announcing the Victor Temperature Regulator Data and Price Book, pertaining to self-contained vapor types of regulators for liquids. Four types are featured. Descriptions and illustrations of applications to fuel oil, desuperheating, liquid heating under various conditions are given. One page is devoted to brief treatment of other Atlas regulating devices.

BLAW-KNOX Desuperheaters are illustrated and described in bulletin No. 1417 issued by the Blaw-Knox Co., Pittsburgh, Pa.

FALK CORP., Milwaukee, announces a Geared-Head Motoreducer, described in its new bulletin No. 261, for relatively low ratios of both speed reduction and speed increase.

MODERN LUBRICATION for Diesel engines, also fuel requirements are fully discussed in a handsome 48-p. booklet issued by Tide Water Oil Co., 17 Battery Pl., New York, N. Y. Subjects covered include proper lubrication development and construction of Diesel engines, lubricating systems and oils, fuel oils, and suggestions for care of lubricants.

MARLEY Small Spray cooling towers are described and shown in detail in Bulletin No. 39 issued by The Marley Co., 1737 Walnut St., Kansas City, Mo. Construction, arrangement of various types and applications are included for capacities from 5 up to 2000 g.p.m.

HOOVER DAM is the title of a sixteen-page fully-illustrated bulletin just issued by The Babcock & Wilcox Co., 85 Liberty Street, New York, N. Y., describing briefly the project as a whole and in greater detail the gigantic welded plate-steel pipes that are to be fabricated and installed in the hydraulic power and normal-flow control tunnels. Among the illustrations in this bulletin are maps of the territory adjacent to Hoover Dam, sketches of the dam and pipe layout, photographs of the Canyon and the tunnels as well as a drawing visualizing the size of a 30-ft. diam. section of pipe weighing 150 t. Copies of this bulletin may be had by addressing requests to The Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.

SIX WAYS to Reduce Power Costs is the title of a bulletin issued by Moore Steam Turbine Corp'n, Wellsville, N. Y., showing applications of various types of steam turbines for specific power and steam requirements, with diagrams of the hookups for the turbines in the different arrangements. Cases covered include factories, municipal electric plants, buildings, oil refineries and central station auxiliaries.

WESTINGHOUSE ELECTRIC & MFG. CO., E. Pittsburgh, Pa., issues a new leaflet describing its Photo-Troller for a wide variety of applications that may be actuated by a beam of light projected from a phototube. Some uses are for opening and closing doors or gates, counting objects, detecting breaks on paper machines or flashovers on commutators and sorting of articles by size or color.

Power Plant Construction News

Ala., Birmingham—City Commission, J. M. Jones, Jr., president, plans installation of pumping machinery and auxiliary equipment for proposed industrial water supply system. Entire program is reported to cost over $2,500,000, and will provide for capacity of about 60,000,000 gal. per day.

Calif., Burlingame—The City Council is considering preliminary plans for a muncipal electric light and power plant. It is estimated to cost about $860,000, of which approximately $475,000 will be used for engine-generator units and other primary equipment.

Calif., Hanford—Guy G. Redwine, care of Cyclops Iron Works, 1837 Merced Street, Fresno, Calif., is at the head of a project to construct and operate a new ice-manufacturing plant at Hanford, to be equipped for an initial capacity of about 30 t. per day. Estimated cost $60,000, with equipment.

Calif., Los Angeles—Hauser Brewing Co., care of Louis A. Hauser, head of Hauser Packing Co., 2300 East Ninth Street, meat packer, recently organized by Mr. Hauser and associates, plans installation of electric power equipment, refrigerating machinery and other mechanical equipment in new brewing plant. Estimated cost about $400,000. Claud Beelman, Union Bank Building, is architect.

Idaho, Lewiston—City Water Department plans fund of about $26,700 for purchase of pumping machinery and filtration equipment for municipal water system, in connection with a 1933 expansion and improvement program.

Ill., Granite City—City Council has called a special election on April 4 to approve plans for a municipal electric light and power plant, and municipal waterworks. Proposed to ask bids for equipment shortly thereafter. W. W. Kerch is city engineer, in charge.

Ill., Heyworth—Board of Local Improvements, E. O. Washburn, president, is having plans completed for a municipal electric light and power plant. Citizens have approved a bond issue of $62,000 for station. Warren & Van Praag, Decatur, Ill., are consulting engineers.

Ill., Marseilles Dam—United States Engineer Office, 333 North Michigan Avenue, Chicago, has plans under way for a new boiler plant at Marseilles Dam. Early call for bids is proposed.

Ind., Anderson—Board of Public Works, City Hall, plans installation of pumping machinery and auxiliary equipment, filtration apparatus, etc., in connection with extensions and improvements in water filtration and softening system. Cost about $200,000. Allen & Vagtborg, Inc., 205 West Wacker Drive, Chicago, Ill., is consulting engineer.

Ind., Madison—Board of Trustees, Madison State Hospital, is considering construction of new steam power plant at institution for central steam heating service. Estimated cost close to $90,000. Proposed to have plans drawn at early date.

Ind., Marion—Construction Division, Veterans' Bureau, Arlington Building, Washington, D. C., has plans under way for a new power plant at institution at Marion, for central heating service. Estimated cost $150,000. Proposed to ask bids at early date.

Ind., Petersburg—Petersburg Water Co., Petersburg, plans installation of pumping machinery and auxiliary equipment in connection with extensions and improvements in water system. Estimated cost $70,000. Charles H. Hurd, Architects and Builders Building, Indianapolis, Ind., is consulting engineer.

Iowa, Fairfield—Common Council is arranging a fund of $375,000 for a municipal electric light and power plant, and contemplates early call for bids for equipment. F. V. Goodman is city clerk.

Iowa, Morning Sun—Town Council has authorized surveys and estimates of cost for a municipal electric light and power plant. An election to vote bonds will soon be arranged. H. L. Cory Co., Redick Tower Building, Omaha, Neb., is consulting engineer.

Kan., Kansas City—Milk Producers Marketing Co., 1615 Minnesota Avenue, plans installation of high pressure boilers, stokers and other power equipment, in connection with an expansion and improvement program at dairy products plant. Entire project will cost over $45,000. Swanson & Besecke, 1217 Orville Street, are architects.

Ky., Owensboro—Simrall Refining Corporation, Union Central Building, Cincinnati, Ohio, plans construction of boiler plant, pumping station and other mechanical units at proposed oil refinery at Owensboro. Entire plant will cost over $100,000.

Mass., Russell—Town Committee, W. O. Johnson, Woronoco, Mass., chairman, is considering purchase of an electric-operated pumping unit and auxiliary equipment in connection with extensions in water system. Plans will soon be completed.

Mich., Detroit—Penton Products Co., 2421 South Smith Street, plans installation of electric power equipment, refrigerating machinery, conveying and other mechanical equipment in new eight-story brewing plant. Entire plant will cost about $375,000. Giffels & Vallet, Inc., Marquette Building, is architect and engineer.

Mich., Midland—City Council is said to be planning construction of a municipal electric light and power plant, estimated to cost about $75,000. Proposed to ask bids in near future.

Mich., Midland—Dow Chemical Co. plans installation of electric power equipment in connection with rebuilding of portion of plant recently destroyed by fire. Loss about $100,000. Company engineering department will be in charge.

Mich., Whitehall—Michigan Public Service Co., Ludington, Mich., is planning extensions and improvements in transmission and distributing lines, including power substation facilities, at Whitehall and vicinity. Estimated cost about $40,000. Company engineering department is in charge.

N. B., Saint John—Gulf Refining Co., Frick Annex, Pittsburgh, Pa., plans construction of boiler plant, pumping station and other mechanical units at proposed new oil refinery at East Saint John, where site has been selected. Large battery of steel tanks will also be installed. Entire project is estimated to cost over $600,000. Company engineering department is in charge.

N. J., Bayonne—Pharma Chemical Co., 169-81 West Fifty-second Street, manufacturer of textile chemicals, etc., plans installation of electric power equipment in connection with proposed rebuilding of portion of plant, destroyed by fire early in March. Loss estimated over $125,000.

N. J., Elizabeth—Wilson-Jones Co., 3300 Franklin Boulevard, Chicago, Ill., manufacturer of loose-leaf binders, etc., plans installation of electric power equipment in new plant at Bayway and Lidgerwood Avenues, Elizabeth, where site has been purchased. Cost about $100,000.

Ohio, Fairfield—Construction Quartermaster, Patterson Field, Fairfield, has plans under way for new steam power plant for central heating service, estimated to cost about $150,000. Proposed to ask bids at early date.

Pa., Alden—Alden Coal Co., Alden, plans installation of electric power equipment, hoists and other mechanical equipment in connection with proposed rebuilding of washery at local coal properties, recently destroyed by fire with loss of about $50,000. Company engineering department will be in charge.

Pa., Brodhead—National Portland Cement Co., care of W. S. Barstow & Co., Reading, Pa., engineers, plans construction of power house and installation of electrical equipment for plant service at proposed new cement mill at Brodhead, for which detailed plans are being arranged by engineers noted. Entire project reported to cost over $1,000,000.

Va., Farmville—Farmville Furniture & Cabinet Co., Farmville, is planning installation of electric power equipment in connection with proposed rebuilding of portion of plant, recently destroyed by fire with loss of about $150,000.

Va., Radford—City Council, Radford, has plans under way for a new municipal hydroelectric power plant on the Little River. A fund of $129,000 has been arranged for project, including transmission line.

Va., Roanoke—Construction Service, Veterans' Administration, Arlington Building, Washington, D. C., asks bids until April 18 for utilities for new hospital unit at Roanoke, for which bids will be received at same time, including refrigerating and ice-making plant, elevated steel water tank and tower, outside electrical distribution system, water-softening system, etc. Entire project will cost about $1,000,000.

Wash., Seattle—Board of Public Works, Seattle, plans early call for bids, closing about April 12, for completion of Diablo hydroelectric power plant and construction of double transmission line, in connection with municipal hydroelectric power project on Skagit River. A fund of $1,620,000 is available for work.

D. C., Washington.—Howard University has been authorized by act of Congress to build its own power plant. Engineering work will probably be in the hands of the University Engineering staff headed by Professor Albert I. Cassell.